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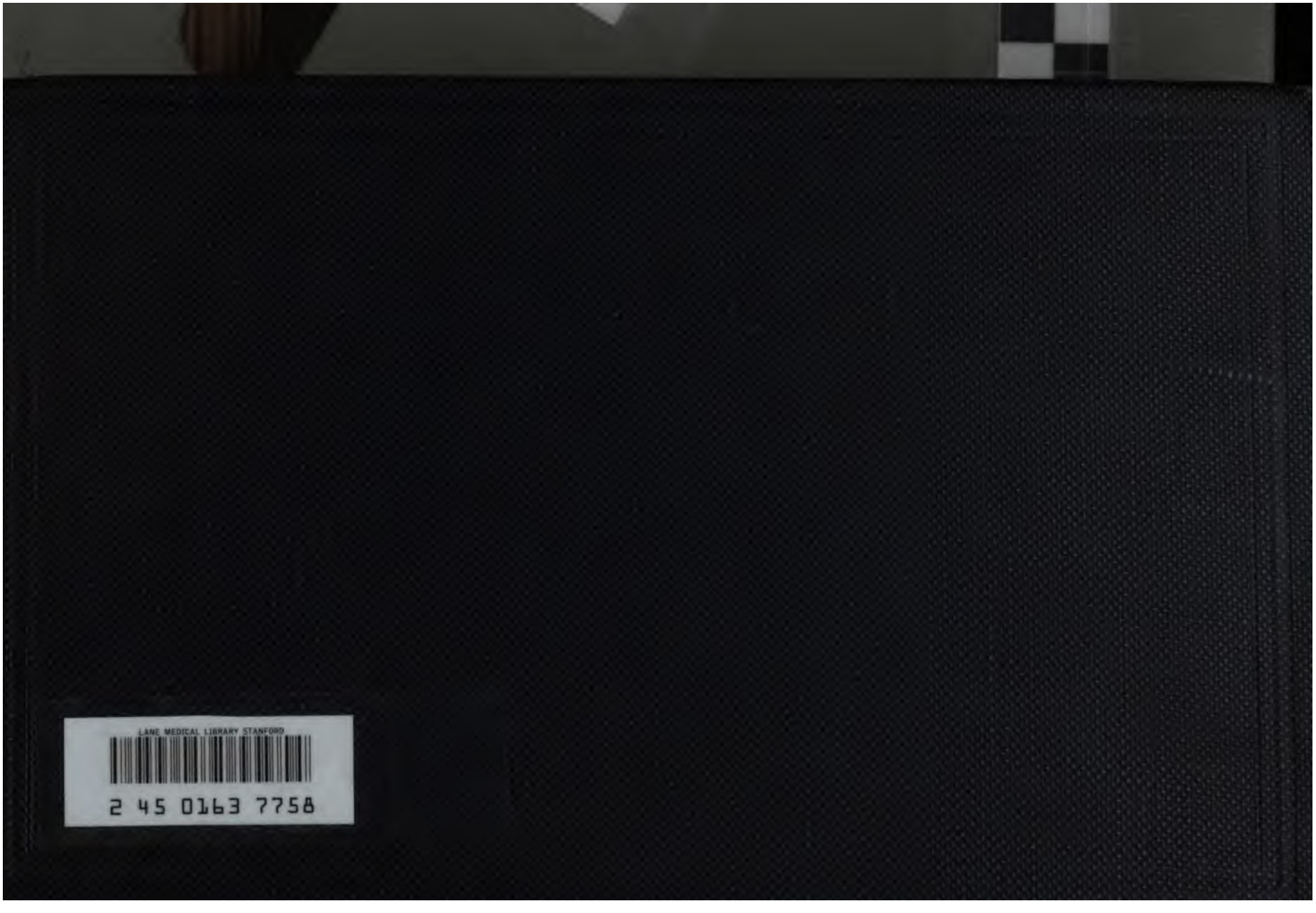
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EDITED BY

JOHN FAIRBAIRN BINNIE, A.M., C.M.

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BY

JOHN FAIRBAIRN BINNIE, A.M., C.M. (Aberdeen); F.A.C.S.

SURGEON TO THE CHRISTIAN CHURCH, THE RESEARCH AND THE GENERAL HOSPITALS, KANSAS CITY, MO.; FELLOW OF THE AMERICAN SURGICAL ASSOCIATION; MEMBRE DE SOCIETE INTERNATIONALE DE CHIRURGIE, MEMBER OF THE WESTERN SURGICAL ASSOCIATION

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PREFACE TO SEVENTH EDITION

In this as in all previous editions great care has been taken to avoid the perspective of a text-book where emphasis must be placed on the common rather than on the unusual operations of surgery. The constant endeavor has been to give aid to the surgeon when he is in trouble, hence much greater space has been devoted to some rather rare operations than to many of far greater every-day importance but which ought to be familiar to every one. Thus a chapter has been included on Cardiac Surgery even although, up to the present, such work has been mostly confined to the physiological laboratory. Several chapters have been rewritten, many obsolete illustrations discarded, new figures inserted and a short chapter on Retroperitoneal Neoplasms added. In spite of much new material careful pruning has prevented any great increase in the size of the volume. At the present time of strife it has been thought wise to append a short chapter on War Surgery. This has been made possible through the kindness of Dr. Walter S. Sutton. It is hoped that the earnest effort to keep the work up to date may have been successful.

KANSAS CITY, MISSOURI.

PREFACE TO SIXTH EDITION

The original plan of this "Manual of Operative Surgery" was to devote attention to the advanced operative surgery of the day and to avoid discussion of those topics which were sufficiently described in the text-books on "The Art of Surgery."

Various reasons have compelled the inclusion of subjects such as were originally excluded, but great care has been taken to avoid using the perspective of a text-book where emphasis must be placed on the common rather than on the unusual.

In this work, the constant endeavor is to give aid and guidance to the surgeon when he is in trouble, hence far more space is devoted to such rare and difficult operations as hypophysectomy, than to many operations of much greater every-day importance, but which ought to be familiar to every graduate.

In the present edition, the chapters devoted to operations on the stomach have been largely rewritten, special attention being paid to the anatomy of the gastro-intestinal lymphatics.

Many other chapters have been rewritten and a new chapter has been devoted to the treatment of tumors in general.

It is hoped that the earnest effort to bring the work up to date may have been successful.

J. F. BINNIE.

PREFACE TO FIFTH EDITION

K. M. BLAKISTON, ESQ.,
Philadelphia,

DEAR SIR:

You suggested to me that our Manual of Operative Surgery should be issued in one volume instead of in two. I thoroughly agreed with you in your suggestion and am glad to say that several friends, whose judgment I trust, concurred in the wisdom of so doing. The original work was issued in one rather small volume in which, for various reasons, no account was given of operations on the bones and joints, etc. Later it was determined to include these subjects. It would have been manifestly unfair to have compelled those who possessed the original volume and who desired the complete work to repurchase what they already possessed—hence, the new material was published in a separate volume. This debt to the above class of purchasers having been fulfilled, I think we are fully justified in returning to the original idea of one volume which is more practical so long as the book is not too large and clumsy.

The present issue represents the fifth edition of Vol. I. and the second of Vol. II. I have endeavored to bring the contents up to date and hope that the book in its new dress man find favor with the medical public.

As on previous occasions I have to thank Dr. John G. Hayden and Mrs. C. M. Bossler for most valuable assistance. Personally, I desire to thank you for the great interest taken in the manual both by yourself and by your very efficient staff.

Yours sincerely,

J. F. BINNIE.

DEDICATORY LETTER

TWELFTH AND WYANDOTTE STS.,
KANSAS CITY, MO.

DR. ROBERT F. WEIR, New York:

Dear Dr. Weir:—Some considerable time ago you encouraged me in a design to write a little book on operative surgery, in which there should be omitted, as far as possible, all description of those procedures which are ordinarily thoroughly given in the usual text-books on general surgery. You were good enough to look over and express approval of the scheme and of certain sections of manuscript submitted to you. This volume is the outcome of your encouragement, and it gives me intense pleasure to have your permission to dedicate it to you.

Following out the ideas already expressed, I have omitted all reference to such subjects as amputations and ligations. Such portions of genito-urinary and of rectal surgery as are fully treated in the common text-books have been passed over in silence. It was my intention to devote considerable space to the operative surgery of the bones and joints, but having prepared several chapters on these subjects, I found that any adequate treatment of them would require a second volume. The exigencies of space forbidding a satisfactory review of the operations on the bones and joints of the extremities, I prefer to omit such entirely. My aim throughout has been to be practical: to describe operative procedures as they are done on the living subject, instead of on the normal cadaver.

For the bibliography of operative surgery, the reader is referred to the Catalogue of the Surgeon General's Library in Washington.

In the preparation of this volume I have had the benefit of much advice and criticism from our mutual friends, Drs. W. J. and C. H. Mayo of Rochester, Minn. Drs. Block and Mark of this city have kindly revised the chapters on genito-urinary surgery. Drs. E. F. Robinson and R. M. Schauffler gave me much assistance in proof-reading, while my student assistant, Mr. Florian, helped me in many ways. To all these gentlemen and to those who generously placed plates and drawings at my disposal, I beg to return heartfelt thanks.

Hoping that this work of mine may never cause you to regret the encouragement given by you,

I remain,
Your friend,

J. F. BINNIE.

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MANUAL OF OPERATIVE SURGERY

PART I.—HEAD AND NECK

CHAPTER I

SCALP

REMOVAL OF SEBACEOUS CYSTS (WENS)

ethod A.—Make an incision through the skin *into* the cyst. The incision **be** nearly as long as the diameter of the tumor. Do *not* squeeze out the **nts** of the cyst. Seize the divided cyst wall with a strong forceps (hemo-

With a twisting motion it is easy to pull out the whole sac. Apply **ire** to the wound for a few seconds. Close the wound with one or more **s.** Dress.

ethod B.—Make a free incision through the skin (which is thin over the **r) down** to, but not into the cyst. Dissect out the cyst unbroken. Close **round.** Dress.

ethod C.—If the cyst is infected and suppurating, treat it either as an **ss or** better excise it plus the infected portion of the skin.

i cases where the cyst is not adherent and not inflamed, **method A** is ex-**ly easy** and gives perfect results; opening the cyst permits removal through **paratively** small cut, and the author has never seen harm result from **e of cyst** contents. Remember that sebaceous cysts occasionally become **nant,** hence look with suspicion on such as do not shell out readily.

ANGIOMA OF SCALP

hen simple nevi of the scalp require removal by operation, the incision **be made** sufficiently far from the disease so that hemostasis may be easily **ed; the** wound, if extensive, may tax the resources of plastic surgery. **ly growing** angiomata, those which penetrate the subcutaneous tissues or **rge and** tumor-like and those which bleed or threaten severe hemorrhage, **ll for** operation.

giomata over the fontanelles often communicate with the longitudinal **hence** in these, radical operation should, if possible, give way to less **ss measures** such as ignipuncture. The same is true in the case of cav-**s angiomata,** which evidently penetrate the skull.

(A) Strangulation.—Pass a stout pin or needle under the middle of the nevus from side to side. Pass a stout thread around the base of the nevus, under the pin (which keeps the thread from slipping). Tie the thread very tightly. Instead of one, two pins may be introduced at right angles to each other. In time the strangulated tissues die, slough off and leave an ulcer. In the twentieth century this treatment savors of barbarism.

(B) Subcutaneous Ligation.—Many methods of subcutaneous ligation have been used; most of them are exceedingly simple.

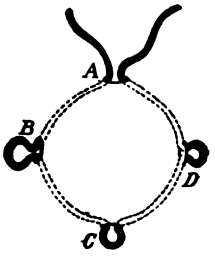


FIG. 1.—Subcutaneous ligation angioma.

I. At the points *A*, *B*, *C*, *D* (Fig. 1) puncture the scalp with a knife. These points must be well away from the disease. With a needle introduce a stout chromicized catgut or a silk suture through *A* and bring it out at *B*, reintroduce at *B* and bring out at *C*; in the same manner carry the suture from *C* to *D* and from *D* to *A*. Both ends of the suture now emerge at *A*. Tie the suture tightly and let its knot retract under the skin through the puncture at *A*. Apply dressings.

II. Krogius ("Centralblatt fur Chir.," Sept. 30, 1905) found that compression and ligation even, of the afferent vessels was inefficient in cases of large racemose (cirsoid) angiomata of the scalp; that ignipuncture, injections and excision were dangerous. He therefore

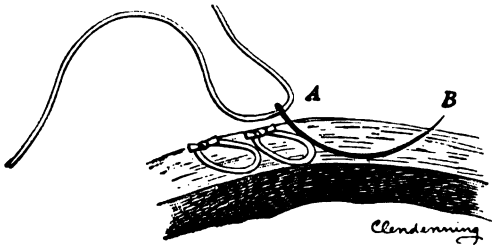


FIG. 2.—Krogius' operation angioma.

devised the following method of subcutaneous ligation: Arm a full curved needle with catgut. Pass the needle from *A* to *B* (Fig. 2), hugging the bone.

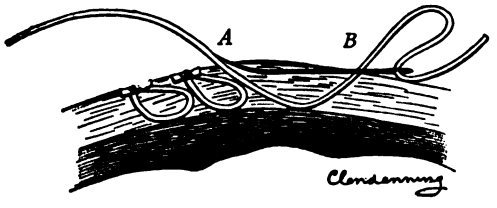


FIG. 3.—Krogius' operation angioma.

Remove the full curved and substitute a less curved needle. With this pass the suture from *B* to *A* immediately under the skin (Fig 3). Both ends of the suture now emerge at *A*. Tie the suture tightly.

Repeat the process *all round* the nevus until practically every vessel entering or leaving the tumor is controlled. Each suture or ligature should to some extent overlap into the territory controlled by the next one.

(C) Bryant's Operation.—Suitable in cases of cirsoid growth. Make an incision outside and nearly round the growth, down to the periosteum. Leave undisturbed that portion of growth containing the largest vessels. Raise the flap and attend to hemostasis. Apply dressings *under* as well as over the flap. When the wound is covered with granulations, replace and suture the flap. If after elevation of the flap for a few days pulsations continue in the flap (the tumor is in the flap), ligate at a distance the main vessel entering it. This method has given J. D. Bryant much satisfaction.

In a case of angioma of the lower frontal region the author operated as follows:

1. Shave the anterior portion of the scalp. Make a tranverse incision over the head practically from ear to ear but inside the line of the hair.

2. Reflect the skin flap thus formed downwards and forwards until the angioma is almost reached (Fig. 4). At this point, if necessary, cut through the deeper structures until a layer of tissue is found *beneath* the angioma and continue the reflection of the flap downwards in this plane until the lower limits of the angioma are passed. Working from the under side of the flap pass sutures or ligatures around the main vessels entering the angioma from the base of the flap.

FIG. 4.

3. Treat the flap as in Bryant's operation and a few days later excise the tumor. Replace the flap and close the wound with sutures. The object of this method is of course to avoid making any visible scar.

Clairmont reports from v. Eiselsberg's clinic ("Archiv. für klin. chir.," lxxxv, 549) an operation which combined the principles of Bryant's operation and excision. Following Krause, the operation was completed in two sittings. Figs. 5 and 6 show the extent of the disease. A skiagram showed that the middle meningeal arteries were much enlarged. The occipital limits of the tumor were clearly defined; elsewhere it was not well delimited. The use of temporary hemostasis by an elastic band was impossible. Preliminary ligation would have called for the tying of both occipital arteries, the frontal artery (the size of the little finger), and both external carotids near their origin, which might cause danger of embolism. Communicating vessels between the scalp and the inside of the skull were so numerous as to make the gain from preliminary ligations very doubtful. The operation performed may be taken as a guide for the treatment of extremely extensive cirsoid aneurysm of the scalp.

Place the patient almost in a sitting posture. Anesthetize.

Step 1.—Make an incision through the skin and epicranial aponeurosis skirting the growth anteriorly and laterally. Make the cut inch by inch, using compression on each side of the cut against the bone until the vessels are secured by forceps and ligatures. Isolate and doubly ligate the main vessels

before dividing them. This incision outlines a horseshoe-shaped flap having its base at the occiput.

Step 2.—Reflect the flap from the cranium. This step requires the use of many hemostats and ligatures because of the free anastomosis with the deep vessels.

Step 3.—As in Bryant's operation, place gauze between the flap and the bone. Replace the flap over the gauze. Apply dressings and bandage.

Step 4.—After three or four days remove the dressings and excise the tumor from the under surface of the flap. Thrombosis of the vessels in the tumor, and loosening of the surrounding connective tissue due to the edema, make the excision of the growth easier than it would have been at the first sitting.

Step 5.—Replace the flap. Suture. Dress the wound.

FIG. 5.

FIG. 6.

FIGS. 5 AND 6.—Cirsoid aneurysm. (*Clairmont.*)

(D) Excision.—It is very easy to excise small nevi and to close the wound with sutures. When large nevi are being excised hemorrhage during the excision may be avoided by tying an elastic constrictor tightly round the head as in trephining or by having a rubber-covered ring (ring pessary) pressed firmly against the scalp surrounding the nevus. The operation consists in excising the disease by cutting through healthy tissue, in securing hemostasis and in closing the wound either directly or by some plastic procedure.

The freezing treatment of nevi threatens to displace all other methods.

Liquid Air.—*First get the liquid air.* Make a very firm pad of cotton on the end of a stick. Dip the pad in liquid air. Shake off any loose drop of the liquid. Press the charged pad with moderate firmness on to the nevus for a few seconds. Repeat the process on every part of the lesion. The treatment is usually painless. Apply no dressings. If any raw surfaces are present on the lesion they must be covered with thin gauze before being treated, otherwise the applicator would freeze to them (Whitehouse); all scabs must be removed prior to treatment.

The applications may require to be repeated two to three times at intervals of about one week.

Carbon-dioxide Snow.—Instead of liquid air, carbon-dioxide snow may be used and is easily obtained in tanks such as are used in commerce. Permit a spray of the gas to play into a bag of chamois leather. Snow is immediately formed. Put the snow into a cylindrical mould of wood or metal and tamp it down firmly with a stick or pestle. Remove the firm candle of snow from the mould and trim it to the desired shape with a knife. Apply the point of the snow-candle, with moderate firmness for a few seconds, to the part to be treated.

MALIGNANT TUMORS OF THE SCALP

The principles of operation are the same as obtain in other situations, viz., free excision and, especially in the case of epithelioma, removal of the lymphatics which drain the site of disease, when this is possible. The main features of the anatomy of the lymphatics of the scalp are as follows:

(*A*) The lymphatics of the frontal, and the anterior part of the parieto-occipital regions, drain into the parotid lymph glands. These glands for the most part lie in the parotid, and their removal means removal of the parotid. A cancer of the scalp, with secondary nodes in the parotid, is practically inoperable.

(*B*) The lymphatics of the posterior part of the parieto-occipital region drain into the mastoid group of glands lying on the mastoid portion of the sterno-mastoid muscle. These are easily extirpated.

(*C*) The occipital region is drained by two routes. From the outer part, the lymphatics join to form a single trunk which runs downwards to a point under the sterno-mastoid muscle, where it enters one of the external glands of the sterno-mastoid group. From the inner part of the region, the lymphatics go to the occipital glands.

From the foregoing it is clear that only in case of frontal and anterior temporo-parietal cancer, are the lymphatic nodes "next in order" really inaccessible. When a cancer of the scalp is freely movable—excise it thoroughly but leave the skull intact; the wound may be closed by sutures, by flaps of skin, or by skin grafts. When the cancer is adherent to the bone, make an incision down to the bone all round the disease, but in healthy tissue. With the chisel introduced through the incision, cut away all the external table of the skull corresponding to the diseased area. If for any reason it is thought that the disease has penetrated the diploë it becomes necessary to remove the whole thickness of the skull. The cranial defect should be closed at once by some plastic method. v. Bergmann writes, "when the disease affects the frontal or occipital regions we do not hesitate to penetrate the dura and remove portions of the cerebral cortex."

CHAPTER II

THE SKULL AND THE BRAIN

EXPOSURE OF THE SKULL

Many means of exposing the skull may be employed, all of which must be preceded by the shaving of a large part, or, still better, of all the scalp. In cases of open fracture, one may expose the bone sufficiently by enlarging the wound already existing. When the operation is for the removal of a foreign body lodged in the bone, a linear incision may be employed. The same incision may suffice to lay bare enough bone for the application of Doyen's perforator or a very small trephine. When a moderate sized trephine is to be used or one desires to explore the surface of the skull, the best incision is one curved in the form of a **U** or horseshoe. Unless specially contraindicated the open end of the **U** should face downwards in the direction of the blood-supply of the scalp. The knife penetrates to the bone at the first cut and the flap is rapidly and readily reflected downwards. Hemostasis must be attended to at once. Before incising

FIG. 7.—Makkas' pin, and forceps for introducing it.

the scalp some surgeons tie an elastic constrictor round the head immediately above the ears so that hemorrhage may be controlled. Lanphear attains the same ends by surrounding the site of operation with a continuous chain suture, each stitch of which includes the whole thickness of the scalp. Makkas surrounds the area of operation with clamps, either straight or slightly curved, which assure a bloodless field, Fig. 7. When operating in a region supplied by the temporal artery, it is convenient to have an assistant exert pressure thereon. The best methods of securing hemostasis are those described in Cushing's decompression operation (p. 25) and in the osteoplastic opening of the skull (p. 14).

METHODS OF OPENING THE SKULL

(A) **The Trephine.**—There are two species of trephine, but of these there are many modifications:

1. The ordinary trephine is, in principle, merely a hollow steel cylinder

whose lower end is provided with a saw-edge. To keep the saw-edge in position on the skull, a pin projects through the centre of the cylinder. The pin is withdrawn as soon as the trephine has cut a groove in the bone sufficiently deep to prevent it from slipping. Power is applied to the instrument through a T-shaped handle or a "brace" similar to those used by carpenters. To prevent any sudden onward movement of the instrument into the brain after the inner table of the skull is penetrated, movable guards may be fixed to the outside of the trephine. (See Fig. 8.)

FIG. 8.—Trephine and "brace."
B. Trephine: 1, Centre pin; 2, movable guard; 3, stem to fit into brace. C. Extra stem by which burs or drills may be attached to brace. (*Monod and Vanverts.*)

2. *The Galt Trephine.*—The principle of this trephine is identical with the preceding except that the cutting part of the instrument is shaped like a truncated cone (Fig. 9). The conical shape prevents any sudden onward movement when the inner table of the skull is penetrated. The Galt trephine is most commonly used in America. The only disadvantage of this instrument is that on account of its shape it necessarily makes the button of bone removed much smaller than the hole left in the skull, a matter of some importance if one intends reimplanting the bone removed.

Trephining.—Place the patient with his head resting on a sand-bag and held steady by the hands of an assistant (Fig. 10). Expose the skull as already described. Make the centre pin of the trephine protrude about one-sixteenth of an inch beyond the cutting-edge and bore it into the skull at the selected site. By steady movements of the wrist, twist the trephine from left to right and right to left until it has cut a groove in the skull. Withdraw the centre pin and proceed with the trephining. As soon as the outer table of the skull is penetrated there will be less resistance to the operation and more escape of blood. As soon as hard bone is again met, proceed with increased caution. The inner table is often very thin. After every few movements of the instrument probe the groove in the skull with the blunt end of a straight needle. If probing shows greater penetration at one part of the groove than another, lessen the pressure of the trephine at that point. The inner table is usually found divided at one place before another; when this is the case, by slightly tilting the trephine the place where penetration has already taken place is avoided while the rest of the skull is being divided. As soon as the bone is divided the resulting button is easily removed and the dura mater exposed. Along the edges of the osseous hole there will always be found projecting spicules; these must be cut away with rongeur forceps. If bleeding from the cut bone is severe, it may be stopped by sponge pressure, or, if necessary, by slightly crushing the bone between the jaws of a rongeur forceps. In the author's practice this last procedure has almost never failed to give satisfaction and to have no subsequent ill results. Horsley's wax (beeswax 7, almond oil 1, salicylic acid 1) applied to the bleed-

FIG. 9.—Galt trephine. (*Tiemann.*)

ing bone is an efficient hemostatic agent. Leonard Freeman finds sterilized chewing gum most convenient for this purpose, but outside of the United States this material will never be within reach. Should there be any intention to reimplant the button of bone removed, it must, at once, be placed in sterile water and kept at a temperature of about 100° F.

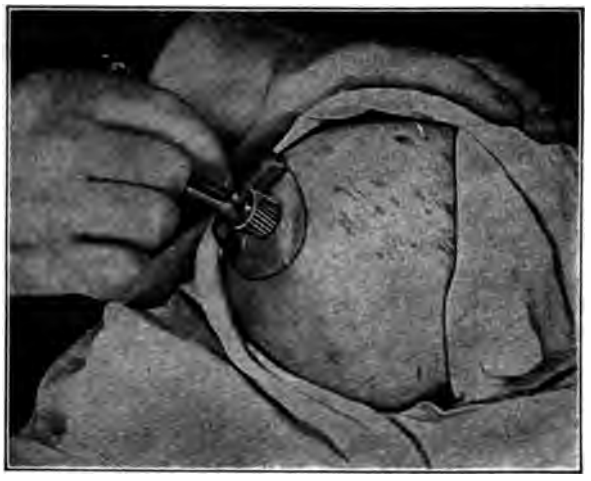


FIG. 10.

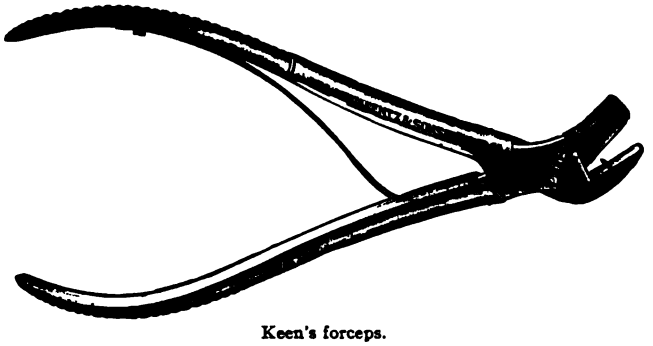
FIG. 11.—Use of Keen's forceps.
Appearance of trap-door opening in skull.

The most convenient size of trephine for ordinary purposes is one three-fourths of an inch in diameter. Smaller instruments are often useful. Trephines having a diameter much greater than one inch are useless owing to the curvature of the cranial vault.

Should it be desired to enlarge the trephine opening, this is easily accomplished by biting away the surrounding bone with rongeur forceps. Keen's forceps are excellent for this purpose (Figs. 11 and 12).

Occasionally the dura is accidentally injured by the trephine and bleeding occurs. When this is the case, enlarge the hole in the skull so that free access is obtained to the dural wound, surround any bleeding vessel by a fine suture, and close the rent in the dura.

DeVilbiss' forceps.



Keen's forceps.

FIG. 12.

(B) Chisel and Mallet.—Especially on the continent of Europe, the skull is frequently opened by means of a chisel. In America and England the method is not a general favorite. The writer has more than once observed severe shock result from it. Either the ordinary chisel or a gouge with a V-shaped cutting-edge may be employed. Support the patient's head on a sand-bag. Expose the skull as already described. Apply the chisel nearly parallel to the plane of the skull, and by careful use of the mallet make it cut a narrow groove in the bone. The groove is gradually deepened until the inner table is divided. Those skilled in the use of the chisel for this purpose can remove or reflect a large piece of skull in a surprisingly short space of time. The chisel is very useful in operating in cases of fracture, especially of fissured fractures, where it is desired to shave away jagged and injured portions of bone. In the formation of trap-door openings through the skull, the chisel was the original instrument employed.

(C) Gigli Wire Saw.—It is desired to remove a large area of skull in one piece. Expose the skull by a U-shaped incision of appropriate size. At each of the four corners of the area to be removed perforate the skull with a small trephine or a Doyen's burr. Doyen's burr is a very efficient and safe instrument, most conveniently operated by a brace or Stille's apparatus (Fig. 13). Before applying the perforator the outer table of the skull ought to be drilled so as to permit the rounded perforator to bite. Hudson's drill is powerful and safe. With a

dural separator, separate the dura from the skull along a line stretching from one trephine opening to another. Introduce an appropriately shaped grooved director to take the place of the dural separator. Pass a Gigli wire saw along the grooved director and leave the director in place to protect the dura. With the wire saw divide the skull from within outwards. Remove the director. Repeat the procedure until the desired area of bone is entirely detached. The Gigli wire saw is an excellent instrument for use in the formation of trap-door openings through the skull.

(D) Forceps.—After perforating the skull as described in the preceding paragraph, one may divide the bone between the perforations with bone-cutting forceps, *e.g.*, Keen's or DeVilbiss' (Fig. 12), and attain the same result as when the Gigli wire saw is employed.

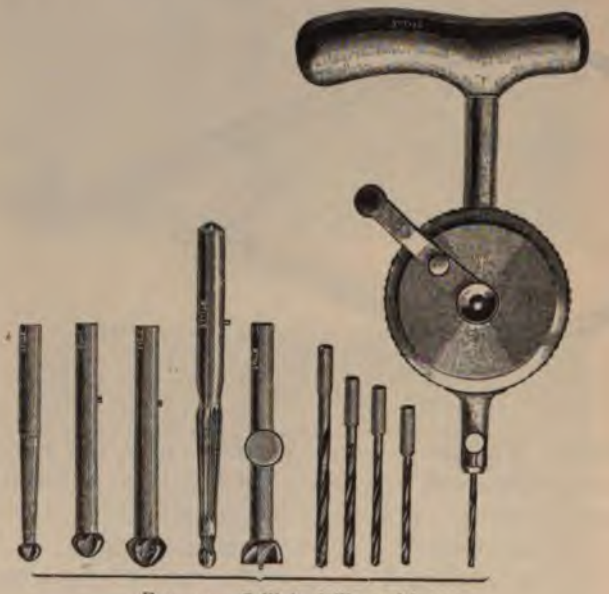


FIG. 13.—Stille's drills and burrs.

(E) Electric Saws, Etc.—Circular saws and drills driven by the surgical engine are used by some busy hospital surgeons as a means of quickly opening the cranium. They are rarely used in private practice, are useful but expensive luxuries, and any full description of their application would be out of place in a work such as this.

In all the methods of opening the cranial vault which have thus far been described the bone is removed over a greater or less area. Is it necessary to close this defect by anything more than replacement of the reflected scalp? When the scalp is replaced, in time the bone defect becomes filled with exceedingly hard and strong fibrous tissue sufficient to protect the cerebral contents from injury by ordinary violence. To prevent the formation of adhesions between the scalp and the cerebral contents many surgeons are in the habit of interposing between them divers smooth aseptic materials cut to such a shape that they will fit into the cranial defect. Of these materials, mention may be

made of gold-foil, celluloid, thin rubber tissue, the membrane which lies between the shell and white of a hen's egg, etc. If the wound remains aseptic, these foreign bodies will lie in place indefinitely. Their use is particularly indicated after operations for epilepsy, but in the ordinary routine of cerebral surgery the author has distinct doubts as to their value.

Carl Beck's method of using the temporal fascia may be employed (see p. 50). As well as free transplants of fascia or of fat.

Macewen fills up the osseous defect with the fragments of bone removed. These he arranges all over the exposed dura like a tesselated pavement. The larger fragments or buttons of bone he breaks into small pieces before implanting them. Excellent results have attended this procedure.

Instead of fragments of bone removed, decalcified bone chips or particles of bone obtained from other patients or animals have been successfully implanted.

Osteoplastic measures have been devised to close defects in the skull with bone. Müller, König and others have formed flaps consisting of the scalp and the outer table of the skull, and with these have covered the defect.

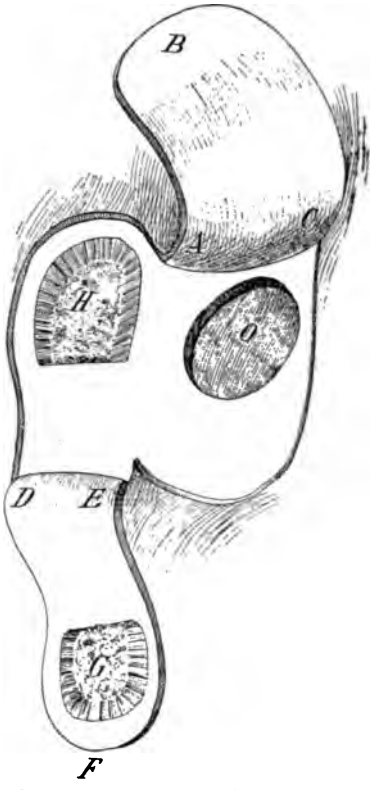


FIG. 14.—Müller-König operation.

MÜLLER-KÖNIG OPERATION

Step 1.—Expose the cranial defect (O, Fig. 14) by reflecting the skin-periosteal flap ABC. Excise all scar tissue from the cranial defect and freshen the edges of the bone.

Step 2.—Outline and reflect the flap DFE. In forming this flap cut away with the chisel a portion of the outer table of the skull (G). The portion of bone G is an integral part of the flap DEF, and is of size and shape suitable to be inserted into the cranial defect (O).

Step 3.—Insert the graft G into the defect O, and suture the edges of flap DEF to the bed from which flap ABC was raised.

Step 4.—Implant flap ABC in the bed from which flap DFE was raised.

The operation may be modified by exposing the whole area ACDE by raising a flap of scalp *without* periosteum and then filling the defect O by bone taken from the area H attached to the periosteum and not to the scalp.

Criticism.—During the necessary manipulations, it is difficult to keep the flap of bone from becoming detached from the pericranium. The pericranium normally has little or nothing to do with the nutrition of the bone. The scar in the Müller-König operation is extremely uncouth. While the author

has successfully used the method, yet he considers free transplantation of bone far easier, at least as successful and theoretically much preferable.

Röpke ("Zent. für Chir.," No. 35, 1912) has used a part of the scapula in the following manner:

1. After exposing the cranial defect by reflecting a flap of scalp, excise the scar tissue over the brain and vivify the edges of the bone. Temporarily pack the wound with gauze wrung out of hot water. Apply dressings.

2. Place the patient on his right side and pull the left arm forwards. Make an incision about ½ inch to the outer side of the vertebral border of the scapula, exposing the fascia covering the infra-spinatus. Divide the fascia and infra-spinatus just external to the vertebral border but do not divide the periosteum. With a sharp knife dissect outwards, cutting the infra-spinatus from the body of the scapula until an area of the bone is exposed fully as large or larger than the cranial defect.

With surgical engine, sharp chisel or suitable forceps, *e.g.*, DeVilbiss', divide the bone all round the desired area, being careful to *leave the vertebral border of the bone intact.*

Dissect the isolated plate of bone from the subscapular muscle. Place the fragment of bone in warm salt solution.

3. Attend to hemostasis. Suture the divided infra-spinatus muscle and fascia to the vertebral border of the scapula. Close the wound. Dress.

4. With scissors carefully remove all muscle attached to the bone implant, and place the bone plate in the cranial defect. Replace the scalp. Close the wound. Dress.

Macewen has long recognized the importance of closing cranial defects; most other surgeons were later in doing so, and many to-day are skeptical or disbelieve in its necessity. The later results in cases of skull fractures treated in Körte's clinic support Macewen's ideas forcibly (p. 17). Stieda ("Archiv für klin. Chir.," lxxvii, 532) formulates the following rules:

1. If the wound can be rendered and kept aseptic, close the defect at once by implantation of the fragments removed (Macewen's method).

2. If the wound is healed—do not wait for the appearance of epilepsy but excise the scar tissue from the cranial defect and repair it by the Müller-König osteoplastic method.

Macewen's method is only applicable for closing the skull at the time the skull is opened, *i.e.*, when the bone removed is available for reimplanting.

In the Müller-König operation the fragment of bone transplanted is supposed to gain its nourishment from the pericranium. In the author's experience, such great gentleness has to be exercised to prevent the fragment of bone from actually falling off the pericranium that it is difficult to imagine any useful amount of nutriment passing from the pericranium to the bone. If this is true, then in view of the success of bone transplantation the complicated Müller-König operation should be discarded and the cranial defect closed by the free (non-pedunculated) transplantation of bone.

This might be accomplished in several ways: v. Eiselsberg did it by using a portion of the tibia covered with periosteum. Undoubtedly the same end could

be attained by implanting fragments of the outer table of the skull obtained in the neighborhood of the defect to be filled.

C. C. Coleman (Surg. Gyn. and Obst., July, 1920) has had large and favorable experience with this method, using a technique which he credits to C. H. Frazier.

1. Excise the scar tissue of the scalp and cranial defect but do not injure the dura. (If the scalp scar is so extensive that after its excision closure of the resulting scalp wound is impossible without undue tension, cover the defect with healthy skin and defer the cranioplasty until later).

2. Make an incision through the pericranium around the defect and about ¼ inch from its margin. With an elevator separate the pericranium along with any remnants of scar tissue from the edge of the defect and with it separate the dura from the bone at the edge of the defect.

3. With a chisel pare the edge of the defect and bevel it. While doing this protect the dura by a thin spatula. Cut a rubber dam pattern of the size and shape of the defect. Pack the wound with gauze wrung out of hot water.

4. Over one parietal eminence make an incision down to but *not* through the pericranium. Retract the scalp. Apply the rubber dam model to the skull. With knife and chisel cut a graft of pericranium and a thin layer of the outer table of the skull the size of the model.

5. Suture this graft (pericranium to pericranium) into the defect, the bony surface being next to the dura.

6. Close the wounds. Dress. It is wise to keep the patient flat in bed for two weeks as the intracranial pressure favored by the horizontal posture, gives the thin transplant the proper curve in relation to the surrounding skull.

Primrose uses not only bone but cartilage for the closure of cranial defects.

Fascial grafts (fatty surface next the brain) are of much value to fill dural defects.

Primrose (Annals Surg., July, 1919) in 34 cases of cranial defects from war wounds where satisfactory closure was accomplished by a firm graft of bone or cartilage obtained the following results.

Cases completely relieved of distressing symptoms	19
Cases rendered worse by the operation	2
Cases improved but not wholly relieved	8
Cases with no change in the symptoms	5

The relief of such symptoms as headache, dizziness, the fear of injury and the sense of insecurity, occasionally the worry and mental depression dependent upon the possession of an ugly deformity is as a rule immediate and complete. The value of the operation in cases of epilepsy is less evident. In one of Primrose's cases the graft became a source of irritation and had to be removed and a fascial graft substituted with relief from the convulsions.

Temporary Osteoplastic Opening of the Skull. Opening of the Skull by Means of a "Trap-door."—This method is often of great value and the flap reflected may be very large. The base of the flap should be in the direction of the main blood supply, *e.g.*, the temporal region where there is the added advantage of having thin bone at the place where the bone pedicle must be fractured.

Step 1.—By scratching the skin, outline the desired flap. On each side of the future pedicle penetrate to the bone. From one of these openings to the other, pass a suitable elevator between the scalp and the bone. Pull a rubber tube through the tunnel thus formed and put it on the stretch. Grasp the two ends of the tube in the jaws of a long bladed clamp (Fig 15). A pad of gauze placed between the clamp and skin protects the latter. Divide the scalp along the line of scratches. The tube and clamp prevents all bleeding from the flap side of the incision. A Makkas' pin can be used instead of the tube and clamp.

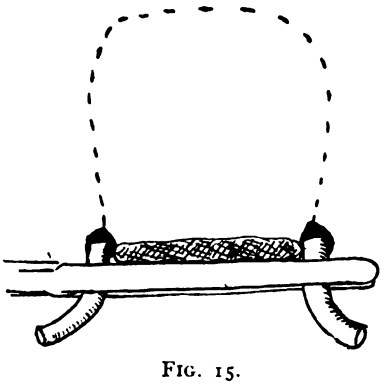


FIG. 15.

Step 2.—At several points along the line of proposed bone section perforate the skull with a burr. Between these openings separate the dura from the skull. Divide the skull between these openings by means of a Gigli saw. While sawing the bone, protect the dura by means of an elevator or thin strip of metal. The bone is thus cut from within outward. It is well to cut so as to make a broad beveled edge. Much of the limbs of the bone flap may be cut with the De Vilbiss forceps or their equivalent. Many surgeons use a surgical engine.

Step 3.—Raise the flap with blunt instruments, fracture its base. At this stage the middle meningeal artery may be injured and bleed, especially if it tunnels the bone. A small pack of cotton pressed between the dura and the bone will control this beeding.

Step 4.—Open the dura by a flap leaving enough margin for suturing.

CLOSURE OF THE SCALP WOUND

The scalp wound is closed by sutures. The author always prefers to introduce as few sutures as possible, because there is little tendency to retraction, and in this locality especially, any fluids which may be thrown out in the wound are very much better soaked up in the dressings than retained beneath the scalp. If few stitches are used, drainage is unnecessary even when thorough cleansing of the wound has been impossible, except in the presence of pus, or when a large cavity has been left after removal of tumor, etc. Drainage of the wound by a strip or wick of iodoform gauze has proved extremely unsatisfactory to the author; the gauze has almost always acted as a plug instead of a drain. Of course, where more extensive drainage or packing is indicated, gauze properly introduced acts ideally. In suitable cases drainage-tubes of rubber, glass or decalcified bone (chromicized)are to be employed.

After closing the wound apply the usual dressings. These are most conveniently held in place by a starch bandage.

HEMORRHAGE FROM THE MIDDLE MENINGEAL VESSELS

The middle meningeal artery enters the cranium through the foramen spinosum, usually accompanied by two veins. It divides into an anterior and a posterior branch, which ramify in all directions over the dura. Meningeal hemorrhage is usually accompanied by fracture of the skull, but as it sometimes is caused by violence which does not injure the bone, and even by *contrecoup*, the operative treatment of the latter class of cases must be considered separately.

I. When focal symptoms permit the determination of the site of the bleeding, the indications for treatment are exceedingly simple. Trephine the skull at the site of the hemorrhage. A tough, dark-colored clot will be found. This must be removed with forceps, probe, spoon, and stream of hot water. Probably the trephine opening will require enlargement; possibly, a second opening may be required, as extradural clots are frequently very extensive. If active

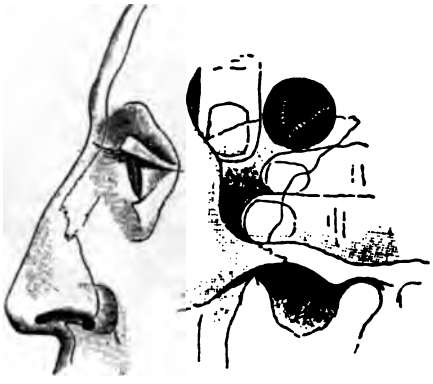


FIG. 16.—Exposure of middle meningeal artery. (*Esmarch and Kowalsig.*)

bleeding continues, search for its source by enlarging the trephine opening with forceps or making another opening as may be required. Ligate the vessel. Examine the dura carefully for signs of injury. If that structure is torn, cleanse the wound from blood-clots and close it with fine sutures. For suturing the author prefers fine silk or celluloid hemp to catgut, merely because the former are so thin that they can be readily threaded on very small needles. If the dura be found distended and discolored, or pulsation is absent showing that subdural hemorrhage is probably present, carefully incise that membrane, remove blood-clot, stop bleeding, and close the dural wound. After the removal of extradural clots the dura soon becomes pushed up against the skull in its normal position, and the external wound may be closed without drainage.

II. In the absence of distinct focal symptoms the trephine must be applied somewhere along the course of the artery so that further bleeding may be stopped and, what is of greater importance, an opportunity may be obtained to explore for and remove the blood-clot. Roswell Park writes: "Vogt and Beck have suggested trephining at a point one and a half inches above the zygoma and the same distance behind the angle of the orbit. An inch trephine at this point is sure to expose the anterior branch of the middle meningeal artery.

Nevertheless, the removal of the clot which causes the compression is much more important than merely finding the artery. Krönlein has made the suggestion of trephining twice, if necessary, in those cases in which the chance of finding the clot is good. He divides these hematomata generally into three classes: (1) fronto-temporal; (2) temporo-parietal; (3) parieto-occipital. He suggests trephining over the artery first, and then, if no hematoma be found and the indications still point to meningeal hemorrhage, to trephine again just below the parietal eminence, because an opening in this position would expose either of the latter classes of blood tumors." (See Cushing's decompressive operation.)

Figures 16 and 17 are self-explanatory.

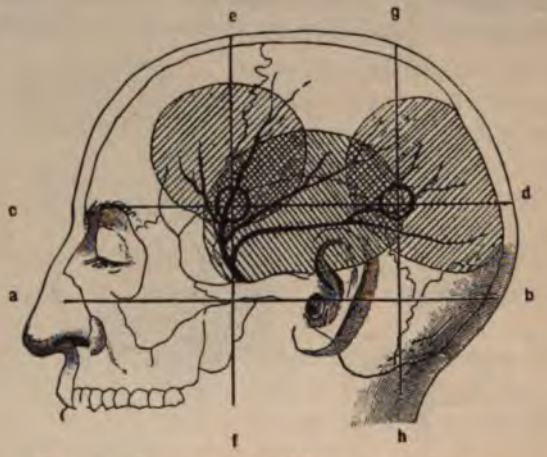


FIG. 17.—Exposure of middle meningeal artery.

a, b. Base line from lower margin orbit through external auditory meatus. c, d. Parallel to a, b. from upper margin orbit, backwards. e, f. Perpendicular to a, b, and about 1½ inches posterior to external angular process. g, h. Perpendicular to a, b, and immediately posterior to mastoid. (*Esmarch and Kowalzig.*)

Steiner has made a careful study of the surgical anatomy of the middle meningeal artery, and as a result has worked out the following method of reaching the vessel.

(A) (1) Draw a line from the middle of the root of the nose to the apex of the mastoid process. (2) From the root of the nose draw a line backwards parallel to a line drawn from the lower margin of the orbit through the middle of the external auditory meatus. (3) Bisect the first line by one drawn at right angles to it.

Where the third or vertical line crosses the second (*i.e.*, that parallel to the base line of the skull) is the point to trephine when searching for the anterior branch of the artery.

(B) To reach the posterior branch of the middle meningeal artery, trephine at the point where a line drawn directly backwards from the root of the nose is crossed by a line drawn at right angles to it from the apex of the mastoid process.

OPERATION FOR FRACTURES OF THE CRANIAL VAULT

In cases of compound or open fracture, the wound in the scalp may be enlarged, so as to expose the skull, or, if more convenient, the scalp may be reflected by the usual U-shaped incision, as is done in simple fractures.

1. **Depressed Fracture.**—The principle to be followed is to elevate the depressed bone, remove all dirt, remove all sharp spicules, stop bleeding, and leave everything in the best possible condition for healing.

If beside the depression there is a sufficiently large hole in the skull, the depressed bone, may be elevated or removed by means of periosteal elevators, necrosis forceps, or rongeurs. It is imperative, especially in compound fractures, to make an opening in the skull large enough to demonstrate the absence of dirt and hemorrhage. Failure to attend to this may be disastrous; the extra work involved in doing it does no harm. If no opening of sufficient size exists in the skull beside the depression, it is necessary to make one. This is usually done with the trephine. Apply the centre pin of the trephine to the solid skull beside the depression. Part of the cutting-edge of the instrument overlaps the fracture, but most of it lies on the unfractured bone. Remove a button of bone. In operating do not exert any pressure on the fractured fragments of bone lest injury to the cranial contents result. Remove or elevate the depressed bone. Remove blood-clot and foreign material. Stop bleeding. If desired, the fragments of bone may be cleansed and returned if conditions are favorable.* If the dura mater is torn, it must be cleansed and sutured. In severe injuries the brain itself is often much lacerated. The cerebral wound must be cleaned by gentle irrigation with hot water and loose fragments of brain removed. Bleeding must be stopped by ligature, application of hot water, or packing with gauze. The divided dura must be sutured, leaving an opening for drainage or for the gauze packing, and the external wound partially closed. When the dura is destroyed to an extent that its closure becomes impossible, it is wise to cover it with some smooth aseptic material, such as gold-foil, rubber tissue, or the like, unless drainage is necessary. Possibly the implantation of a free mass of fat might be of value (see p. 52). Schulze-Berge has covered the dural defect by splitting the neighboring dura into two layers from the outer of which he formed a flap sufficient to fill the defect. When a drain is required, the part of the brain bereft of dura must be left largely to itself. In one case of the writer's where there was much destruction of brain and dura and the wound was infected the patient recovered perfectly in spite of the appearance of a hernia cerebri. The patient was seen several years after the accident and enjoyed perfect health. Twelve years later epilepsy developed.

When the fracture is situated over the longitudinal sinus the sinus is liable to be wounded. Bleeding can commonly be controlled by means of packing.

* Brewitt ("Archiv für klin. Chir.," lxxix) studied the late results of Körte's cases of complicated fracture of the skull. Of thirty-eight patients treated by reimplantation of the bone twenty-four remained in good health, two had slight and two such severe disturbances that they were unable to work. None were epileptic. Three out of four cases treated by a secondary plastic operation were in good health, one had considerable trouble. Out of thirty cases where the skull was left open only nine remained in good health; two had slight, one severe disturbances; one had epilepsy; eight died from the injury; nine cases could not be traced.

Wounds of the sinus have been sutured but its stiff hard walls do not lend themselves easily to direct suture.

Revenstorf ("Centralblatt für Chir.," Sept. 21, 1907) recommends the insertion of a suture such as is sufficiently shown in Fig. 18. The stitch seems as if it would be inefficient but the blood pressure in the sinus is so low that the pressure exerted by the suture suffices.

2. **Fissured Fractures.**—When the fracture consists of a fissure involving *both tables* of the skull, the dangers to be combated are: (*a*) In compound fractures, dirt. (*b*) Intracranial hemorrhage. (*c*) Separation of spicules from the internal table and injury to the brain from them.

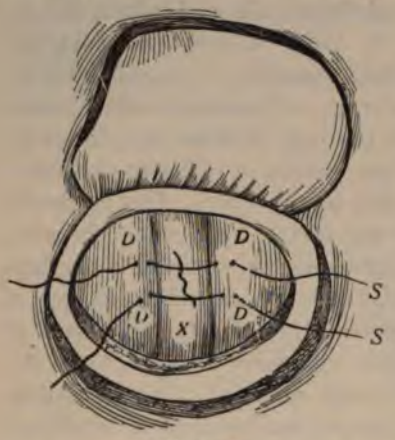


FIG. 18.
X, Longitudinal sinus with rent in it; *S*, *S*, sutures; *D*, *D*, dura.

These dangers are met as follows: In compound fracture, that portion of the fissure near the scalp wound must be treated on the lines laid down for depressed fracture, and the rest of the fissure treated as if the fracture was of the simple variety. In simple fracture the fissure should be exposed, and with a small trephine, rongeurs, or chisel the skull removed at various points along the line of fissure sufficiently to permit the surgeon to satisfy himself as to the absence of hemorrhage or of the penetration of the brain by spicules of bone.

When the fissure does not involve the inner table of the skull, as demonstrated by probing with the blunt end of the needle, it is to be left undisturbed, unless in the neighborhood of a wound of the scalp. When exposed to dirt, as is always the case in compound fractures, the fissure should be cleaned by shaving its edges with a sharp chisel. Fissured fractures are usually met with radiating from other fractures of the cranial vault.

All fractures of the cranial vault ought to be subjected to exploratory operation whether they are depressed or not. J. Abadie (La Pr. Med., Sept. 25, 1916) gives the following advice.

1. Unless entirely and certainly superficial every wound of the scalp ought to be explored by incision.

2. Every injury (even superficial) to the skull ought to be explored. In cases where there is a mere shallow grooving like a scratch made by a nail it is wise to cut into the bone with a saw to demonstrate the intactness of the diploe and that the probe cannot depress the inner table.

3. In all other cases the skull should be opened, fragments removed and edges smoothed.

4. The general condition of the patient can present no contraindication as, in the apparently dying, coma may disappear after operation and operation cannot increase the dangers inherent to the wound.

5. A saw or trephine is preferable to chisel and mallet in operating. The rongeur is excellent but should cut and not crush the bone.

6. If the dura has been penetrated, bone ought to be removed for at least 1–2 c.m. beyond the dural wound to permit certain removal of splinters of the inner table. It is not necessary to remove the uninjured outer table from over the site of the removed splinters of inner table.

7. If the dura has not been opened by the injury ought it to be left intact? Abadie finds incision of the dura does not increase the danger and has seen foci of infection form under the unopened dura which might have been avoided by timely opening. If there is blood under the dura or a focus of attrition (evidenced by depressability) open the dura and after evacuating, let the edges of the wound fall together.

8. If the dura is torn, explore with the finger and remove any splinters.

9. Drain with a gauze wick kept wet with hypertonic salt solution.

10. Unless drainage is to be used, place gauze soaked in 4 per cent. Collargol in contact with the dura (or brain) temporarily.

11. In non-infected cases without dural wound, close the wound completely. Generally part of the wound should be left open for drainage.

12. Progressive headache, a rising temperature or marked slowing of the pulse call for lumbar puncture.

13. Portions of projectiles not directly accessible at the primary operation should be removed two or three days later under guidance of radioscopy.

14. The after history is either entirely good or entirely bad. If there is any 'upset' even on one day, the prognosis is bad. "This rule is not absolute, we have personal experience to the contrary, but it is the general clinical impression."

Fractures of the base of the skull when they demand operation do so on account of secondary complications such as hemorrhage and more especially infection. The operation consists in exposure (and if necessary incision) of the meninges low down. The middle fossa is the one most commonly affected and may be reached by Cushing's decompression operation. In an exhaustive paper ("Annals of Surg.," June, 1910) Ransohoff comes to the following conclusions:

"1. There will always be a large mortality connected with basal fractures—death resulting from primary shock, brain laceration or hemorrhage. Thirty-seven per cent. of the fatal cases die within six hours or less, and 56 per cent. die within twelve hours. It is not probable that the mortality of this class of cases can ever be reduced with or without operation. They are primarily fatal.

"2. Twenty-three per cent. of the fatal cases die during the second twelve hours of the first day and 6 per cent. die during the second day. They are the cases in which the coma is not profound, in which the pupils are not fixed, in which the breathing is not stertorous, and in which there is not complete muscular relaxation. With a slow full pulse and lumbar puncture indicating hemorrhage and increase of intracranial pressure, a trephining operation is indicated. In the doubtful cases, an operation is indicated.

"3. In this class of cases, where facilities for the major operation of trephining are not at hand, repeated lumbar punctures should be essayed. This procedure may be destined to take the place of decompressive operations.

"4. There is a large group of cases in which there is complete consciousness

or in which there is a somnolence or milder degree of coma, and in which the concomitant symptoms do not indicate a grave intracranial trauma either to the brain or its vessels. The pupils though uneven, react; involvement of one or more cranial nerves may be evident. The symptoms singly or collectively are not ominous at any time. Eighty per cent. of this class of cases have a tendency to get well with or without operation. They should not be operated on unless the symptoms indicate an increase of intracranial pressure from hemorrhage or beginning cerebral edema, or distinct localizing (cortical) symptoms.

"5. There is a distinct class of cases in which operation is indicated. They are cases which seemingly not severe in the beginning grow progressively or suddenly worse, showing signs of increased intracranial pressure. Decompressive operation may save a considerable proportion of them.

"6. It has yet to be determined where the trephining should be done to obtain the best results. Since most fractures involve the anterior or the middle fossa, subtemporal trephining is doubtless the procedure oftenest indicated. When, however, a hematoma in the mastoid or occipital region indicates an involvement of the posterior fossa, the operation should be subtentorial. To relieve the subtentorial tension by an opening made in the temporal region is illogical and may be dangerous. I attempted it recently in a cerebellar tumor the site of which could not be determined. The patient succumbed within two weeks with symptoms of bulbar paralysis."

During 1920 the subject of trephining in basal fractures was discussed at length in the Paris Surgical Society ("Bul. et Mem. de la Soc. de. Chir. de Paris, 1920). The general opinion was in favor of spinal puncture as opposed to decompressive operation. De Martel however declared that when a patient with cranial fracture was comatose, lumbar puncture should be done. "If the puncture gave passage to a bloody liquid, flowed freely and was followed by a slight amelioration, it was proper to make a series of such punctures. If the puncture did not give the above results bilateral subtemporal trephining should be practiced as by this means alone could rupture of the meningeal be recognized, lumbar puncture facilitated and rendered inoffensive and effective decompression of the brain realized."

REMOVAL OF TUMORS FROM THE BRAIN

Description of the methods of diagnosing and locating tumors of the brain would be out of place in this work. The diagram (Fig. 19) here presented is merely meant to act as a graphic reminder of the generally accepted position of some of the chief centres. Sherrington and Grünbaum find that in monkeys all the motor centres are *anterior* to the fissure of Rolando. F. Krause ("Die deutsche Klinik," viii, 961) has substantiated these findings in man. Fig. 20 represents, on the left hemisphere, the results of Krause's investigations in twelve operations. J. C. DaCosta and others agree with Sherrington's views. It is necessary, however, to study the relations which the sulci and convolutions of the brain bear to certain landmarks on the skull, so that it may be possible to expose the brain at the desired spot.

FIG. 19.

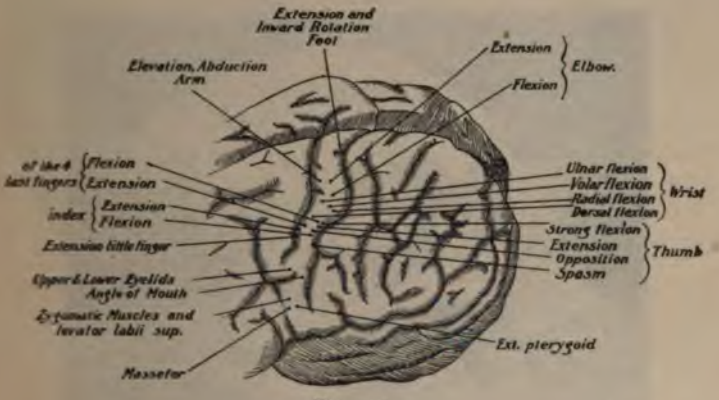


FIG. 20.

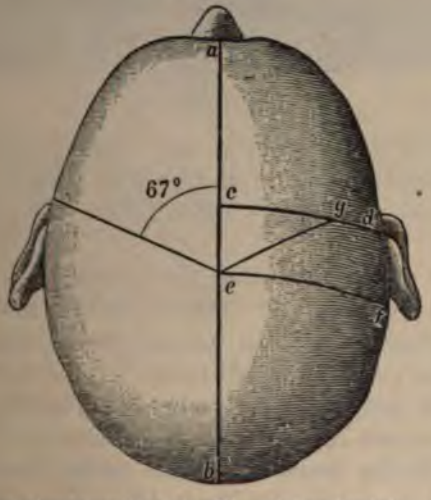


FIG. 21.—Bennet's method shown on the right; Thane's* on the left. (*Esmarch and Kowalzig.*)

* *Thane's Method.*—Draw the line *a–b* (Fig. 21) from the root of the nose to the external occipital protuberance. Take the point *e*, three-fourths of an inch posterior to the middle point of *a–b*. A line drawn forwards and outwards from *e*, at an angle of 67 degrees to *a–b*, corresponds to the fissure of Rolando.

The simplest and most easily remembered means of finding the fissure of Rolando is that devised by Bennet (Fig. 21). At right angles to the sagittal suture draw two parallel lines, the anterior of which (*c–d*) runs along the anterior margin of the external auditory meatus; the posterior (*e–f*) touches the posterior margin of the mastoid process. These two lines will be about two inches apart. On the anterior line take a point (*g*) two inches above the external auditory meatus, and from it draw a line (*g–e*) upwards and backwards to the point where the posterior line meets the sagittal suture. This oblique line is about three and three-quarter inches in length and corresponds to the Rolandic fissure.

The simplest means to find the point of bifurcation of the Sylvian fissure is the following (Esmarch): Draw a line one and one-half inches above and parallel to the zygoma. Draw a vertical line three-quarters of an inch posterior to the frontal process of the malar. These two lines cross at a point correspond-

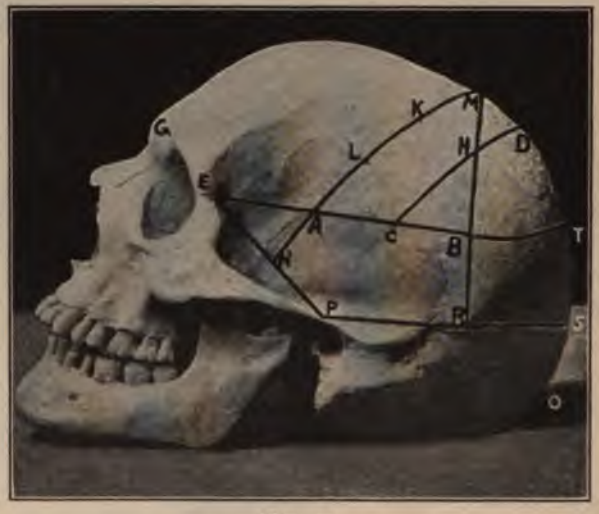


FIG. 22.

ing to the bifurcation of the Sylvian fissure. Vogt's method of finding the same spot is more easily remembered. The desired position is two finger-breadths above the zygoma and one thumb's width behind the frontal process of the malar (Fig. 16).

A more elaborate system for finding the cortical centres is that of Chiene ("Sajous' Annual," 1895) (Fig. 22): "Shave the head and find, in the median line of the skull, between the glabella (G) and the external occipital protuberance (O), the following points: The mid-point (M), the three-fourths point (T), and the seven-eighths point (S). Find also the external angular process (E) and the root of the zygoma (P) immediately above and in front of the external auditory meatus. Having found these five points, join EP, PS, and ET. Bisect EP and PS at N and R; also bisect AB at C and draw CD parallel to AM. The pentagon (ACBRPN) corresponds to the temporo-sphenoidal lobe, with the exception of its apex, which is a little in front of N. MDCA corresponds to the Rolandic area containing the fissure of Rolando, the ascending frontal and the ascending parietal convolutions. A is over the anterior branch of

the middle meningeal artery and the bifurcation of the Sylvian fissure; AC follows its horizontal limb. The lateral sinus at its highest point touches the line PS at R. MA corresponds to the precentral sulcus, and, if it be trisected at K and L, these points will correspond to the origins of the superior and inferior frontal sulci. The supramarginal convolution lies in the triangle HBC. The angular gyrus is at B."

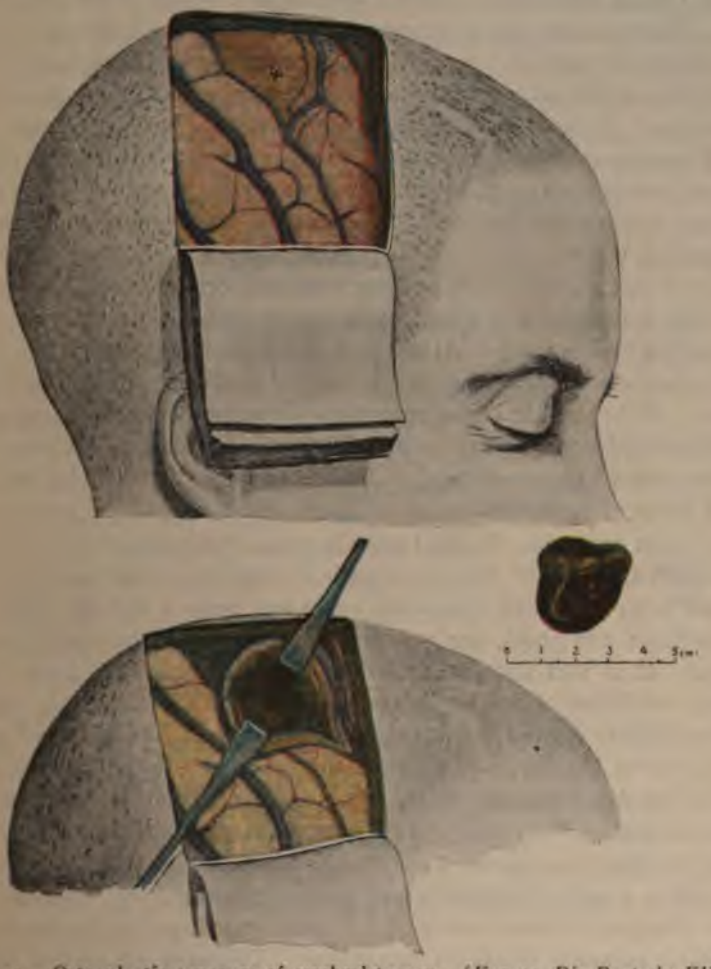


FIG. 23.—Osteoplastic exposure of cerebral tumor. (*Krause, Die Deutsche Klinik.*)

Having determined by measurement, etc., the point at which removal of bone will expose the tumor, mark that point on the scalp with iodine, nitrate of silver, the point of a cautery, or, what is far better, puncture the scalp with a small drill which at the same time marks the outer table of the skull. If it seems proper, any desired areas of the skull may be mapped out by a series of drill marks.

Step 1.—Reflect the scalp and open the skull as already described. Generally one of the osteoplastic or trap-door openings is best. If the patient is weak

or if there has been much loss of blood and shock sustained during this step of the operation, attend to hemostasis, apply dressings, and defer further proceedings for a few days. If the tumor cannot be removed, the mere opening of the skull often relieves distressing symptoms, *e.g.*, agonizing headache.

Step 2.—Examine the exposed cranial contents both by inspection and palpation. In cases of tumor and blood-clot it is usual to notice an absence of cerebral pulsation and the dura often bulges into the trephine opening. By palpation tumors have been correctly located at a depth of one inch from the surface. Fig. 23 shows the appearance of a subcortical gliosarcoma in the arm centre, before and after incision of the meninges. Having recognized and determined the superficial boundaries of the growth, reflect the dura mater as a U-shaped flap. If the dura is involved in the growth, part of it must be sacrificed. When encapsulated, the tumor itself is removed by careful dissection with blunt instruments; a plain silver teaspoon is very useful for this purpose. Infiltrating tumors are unsuited for operation. Hemorrhage is arrested by gentle ligation of vessels when this is possible; by the application of gauze pads wrung out of hot water and by packing with iodoform gauze. The cavity left in the brain may require drainage by means of gauze, but the brain soon expands and fills up the space. After the active operation is completed, close the wound in the dura and scalp, leaving of course, an opening for the emergence of the gauze. If the skull has been opened by the trap-door method, enough bone must be removed from the flap to permit of proper drainage. When a portion of the dura mater has been excised, it is well to protect the brain by the application of a layer of rubber tissue or celluloid. This measure is only feasible if drainage is not required. If the tumor is cystic, drainage of the cyst is often recommended as sufficient, but in the author's experience this has proved futile, and he has been compelled to operate again and remove the cyst-walls.

Hemorrhage and shock are not the only dangers to be feared in cranial operations. It is well known that when the ventricles have been opened a dangerous condition of hyperpyrexia may develop. (Bergmann, de Verco, Parry Davenport: quoted by A. Broca, "Precis de Chirurgie Cerébrale," p. 323.) Sir Victor Horsley is of the opinion that a thermo-taxic centre exists in the cortex and that when this centre is injured a condition of hyperpyrexia prevails independently of any injury to the ventricles. One case seen by the author, in which the skull was opened with chisel and mallet but the dura was undisturbed, died in a state of marked hyperpyrexia before sufficient time had elapsed for septic changes to have developed. Another case reported to the author by H. E. Pearse supports Horsley's contention. This case was one of depressed fracture. At the operation a rubber drainage-tube was inserted. Immediately the temperature rose to a high degree. The dressings were removed and the drain was found to have slipped between the skull and brain. On removal of the drain the temperature returned to normal and the patient made an uninterrupted recovery.

DECOMPRESSIVE OPERATIONS ON CRANIUM

Macewen, Horsley and others have found much good follow exploratory opening of the cranium in cases where tumor was present but could not be

removed. The opening in the skull permits the tumor to grow without exercising so much pressure on the cranial contents. Under such circumstances the non-elastic dura is capable of keeping up injurious pressure, hence when decompression is desired the dura should be incised or a portion of it be excised.

Operations of the class referred to are known as "decompressive operations."

Whenever feasible, tumors of the brain should be removed, but frequently it is impossible to find the location of the tumor or to remove the tumor if its precise situation is known. Under the above circumstances a decompressive operation at the site of election is indicated not as treatment of the tumor but as treatment of the distressing symptoms, vomiting, headache, choked disc, etc.

If the tumor is believed to be in the cerebrum, Harvey Cushing has shown that it is advantageous to open the skull under the temporal muscle. In this situation the bone is thin and non-vascular, while the temporal muscle and fascia, if properly preserved, form an efficient covering for the brain and prevent an undue hernial protrusion in case there is a great increase of intracranial tension. If the tumor is below the tentorium cerebelli the skull may be opened through the occipital bone.

Method A.—**Cushing's Subtemporal Decompression Operation.**

Step 1.—From a point immediately in front of the attachment of the ear make an incision upwards and slightly backwards for about three inches (Fig. 24). Do not employ a curvilinear incision in the scalp. The cut penetrates the skin and galea but *not* the temporal fascia. While making the incision the surgeon controls bleeding from one side of the wound by pressing the scalp against the skull, the assistant exercising similar pressure on the other side, and at the same time controlling the temporal artery by pressure with one finger.

FIG. 24.

Before releasing the finger pressure, clamp the galea with hemostats about ½ inch apart. When these hemostats are laid flat on the scalp the galea will cover the edge of the skin wound, and control bleeding (Fig. 25).

Step 2.—Cut through the temporal fascia and muscle to the bone. At the upper end of the incision never separate the fascia from its bony attachments. If there is bleeding from the lower end of the wound pack a strip of gauze between the muscle and bone.

Step 3.—Free the muscle from the squamous portion of the temporal bone over an area about 3 inches in diameter. To gain access to the denuded area Cushing raises and retracts the soft parts by double angled retractors.

Step 4.—Penetrate the skull by means of a suitable burr. Separate the dura from the bone. Do this with particular care, downwards and forwards because of the middle meningeal vessels. If the operation is performed for purposes of drainage as in fracture, a small opening suffices, if for decompression as in cerebral tumor, the opening must be as large as the temporal muscle permits.

Step 5.—The large cortical vessels are visible through the dura. Cut

through the dura at a spot free from these vessels but do *not* injure the pia-arachnoid. Enlarge the opening by cutting on a grooved director. In case of a fracture explore toward the base beneath the temporal lobe and remove clots, etc. The object of the operation in tumor cases is to relieve tension and preserve vision when the growth is unlocalizable or irremovable. If a tumor is unexpectedly encountered, unless a cyst which may be emptied, it should be left *in situ* until later when an osteoplastic procedure can be carried out to expose it, temporary dependence being placed on the relief of tension to ameliorate symptoms.

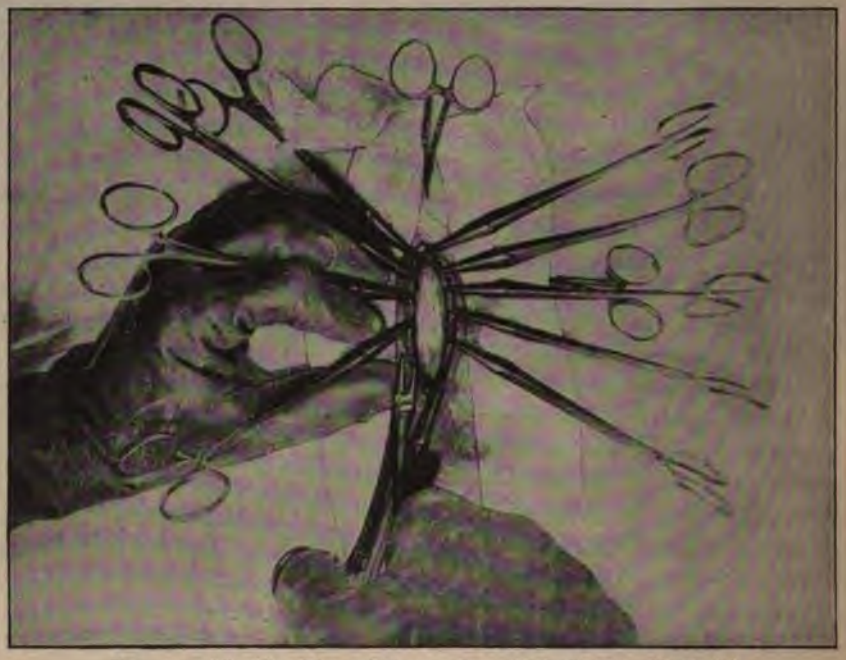


FIG. 25.—(*Cushing Manual Neuro. Surg. Med. Depart., U. S. A.*)

Step 6.—Close the temporal muscle with interrupted sutures of fine silk (Cushing). In the same way close the temporal fascia. These two structures will prevent undue cerebral herniation.

Step 7.—Suture the galea very carefully, the stitches being placed fairly close together and cut close to the knot.

Step 8.—Introduce fine silk skin sutures on straight seamstress needles, leaving the needles *in situ* until the last one is in place. This everts the skin margin and brings a broad area of the cut surface into approximation. The skin sutures may be removed in 48 hours.

William Sharpe (Am. Journ. Med. Sc., June, 1916) advised unilateral or even bilateral subtemporal decompression in cases of 'Steeple Skull' (Thurmschadel) or oxycephaly ic which there is optic atrophy beginning from intracranial pressure. The cranial deformity consists essentially of a very high forehead towering over the face, of poorly marked supraciliary and temporal ridges and in severe cases of a protrusion at the anterior fontanelle. There is

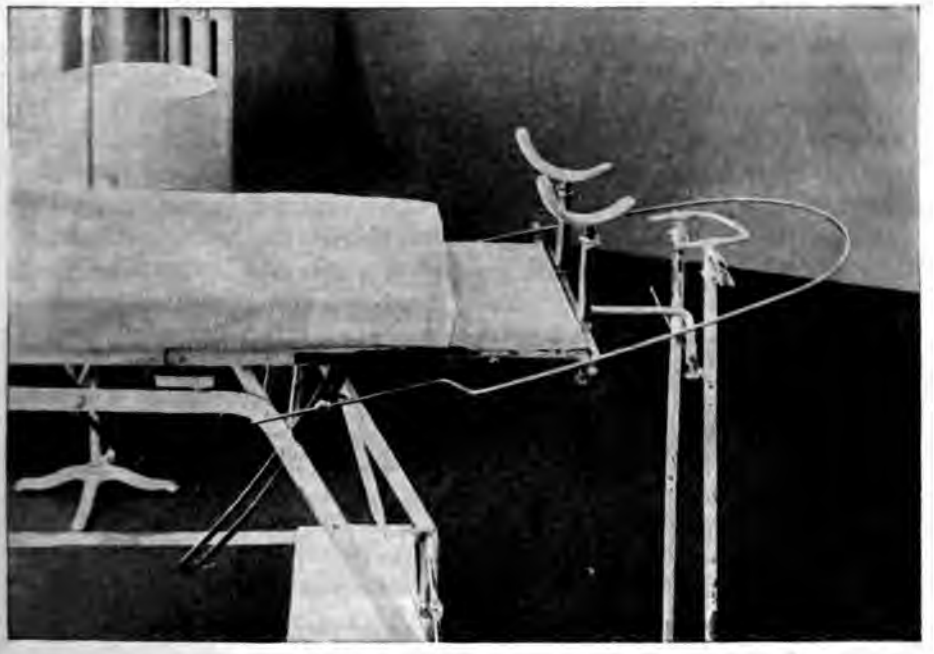


FIG. 26.—Showing outrigger for head and adjustable shoulder supports: before padding: also hoop to support sheets. (*Cushing*, "Tumors of Nervus Acusticus.")

FIG. 27.—Patient in position before anesthetization (*Cushing*, "Tumors of Nervus Acusticus.")

present exophthalmos, divergent (rarely convergent) strabismus and impairment of vision. Without operation, once symptoms have arisen they tend to progress and few, if any, of the patients reach maturity. The few cases reported by Sharpe are encouraging.

Bilateral Exposure of the Cerebellum. (Cushing. Tumors of the Nervus Acusticus, 1917.)—This operation may be used as a means of decompression in cases of unlocalized subtentorial lesions or for the exposure and removal of tumors of the cerebellum or of the acoustic nerve. In Cushing's hands the operation, when it includes the removal of a tumor, may be extremely long (three hours or more) but reasonably safe, the operative mortality in the acoustic cases having fallen to about 11 per cent., whereas it was formerly over 50 per cent.

Preparation of Patient.—Omit breakfast. Give an enema if necessary. Shave the back of the head (Fig. 27) on the morning of the operation.

The operating table is shown in (Figs. 26–27). The patient lies prone on a thick mattress. The shoulders are supported on well-padded crutches, the forehead is carried by a padded outrigger.

The anesthetic, ether, is administered by means of Connell's apparatus.

Preparation of the Field.—Wash with green soap on a gauze sponge. Wash with alcohol and then with bichloride solution as the patient is getting well under the anesthetic. Mark the proposed lines of incision by a knife scratch. The transverse curvilinear incision runs from mastoid to mastoid arching about 4 cm. (1½ inches) above the occipital protuberance. The vertical incision runs downwards 9 or 10 cm. (3½ inches) exactly in the middle line.

Cover the whole field with a large layer of bichloride gauze. Drape everything, except the exact field of operation, with sheets which form a tent for the anesthetist. Sheets should be pinned or clipped to the skin around the field of operation. No towel should slip or be changed during the operation, hence the importance of marking the proposed lines of incision prior to draping and hiding anatomical landmarks.

Step 1.—With finger pressure control hemorrhage while making the curvilinear incision which divides the scalp and galea (epicranial aponeurosis). Before releasing the finger pressure, pick up the galea and the principal suboccipital vessels with hemostats. Lay the hemostats flat on the skin, thus folding the galea over the edge of the scalp wound (Fig. 28) and so preventing subsequent bleeding. Reflect the curved flap downwards to slightly below the occipital protuberance and the muscular attachment of the superior curved line. Make the vertical incision (Fig. 29) exactly in the midline through the intermuscular spaces to the skull and the spines of the upper vertebræ. Apply clamps symmetrically on the two sides as guides for future closure. The vertical incision shows the exact level at which the transverse cut should be made along the line of muscular attachment. Apply a distinctive forceps on each side to the two upper edges of the vertical incision in the fascia (Fig. 29). Divide the fascia along the superior curved line and reflect it downwards. Treat the muscle similarly. Leave enough of the fascia and muscle attached to the bone to serve for subsequent suture. With an elevator separate the muscle from the bone on each side far enough to expose the margin of the fora-

men magnum, the edge of each mastoid and well down under the occipital bone on either side. Bleeding from emissary vessels may be controlled by plugging with Horsley's wax or a fragment of muscle. With a burr open the skull. Enlarge the openings with rongeurs (Fig. 30) to the full extent of the denuded area. The lower margin of each lateral sinus is usually exposed.

FIG. 28.—Showing control of incision for completion of incision. (*Cushing*, "Tumors of Nervus Acusticus.")

Bone wax may occasionally be required to stop bleeding. Often it must be applied after each bite of the forceps during the removal of the thicker bone in the mid-line.

Opening of the Dura.—Should an opening be made over one of the hemispheres the cortex would protrude and be damaged because of increased intra-

dural tension. To avoid this make a minute opening through the dura near the foramen magnum so as to withdraw fluid from the posterior cistern. If this fails to lessen tension do not enlarge the opening but at once tap the lateral ventricle. To do this retract the scalp in the subaponeurotic layer and burr a hole through the skull about 3–4 cm. (1¼ inches) above the superior curved

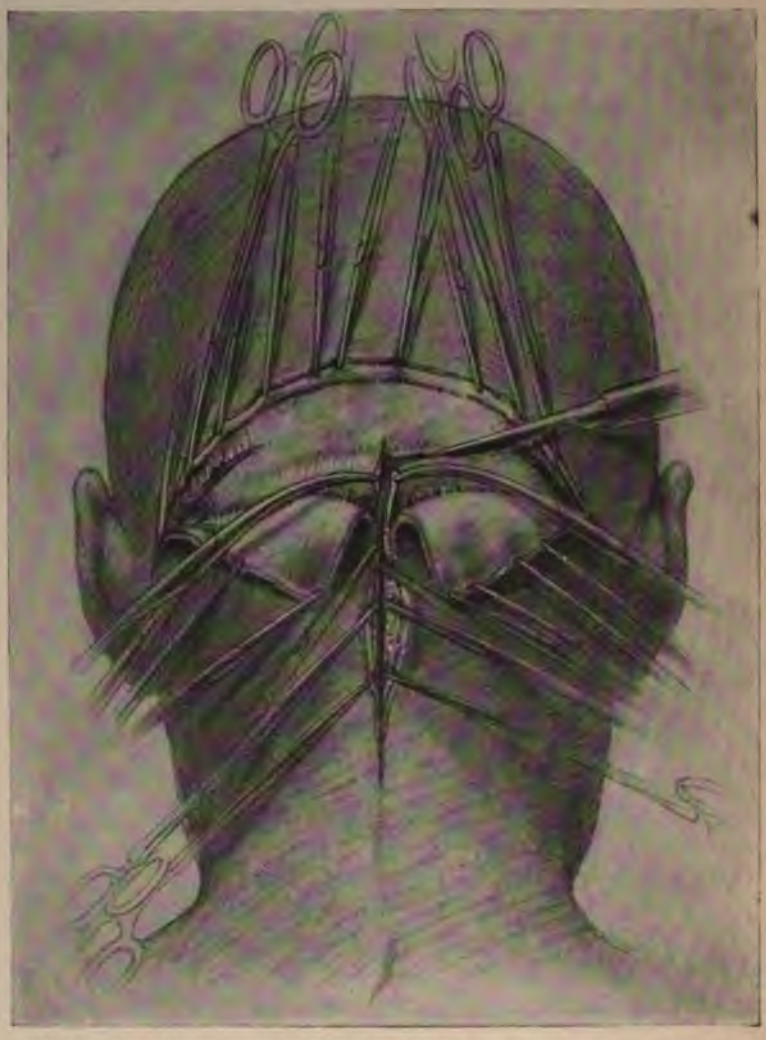


FIG. 29.—Mid-cervical incision carried to spine. Placement of identifying clamps on corners before lateral incisions are made through. (*Cushing*, "Tumors of Nervus Acusticus.")

line and 2 cm. (¾ inch) from the midline. Through this hole pass a blunt cerebral aspirating needle slightly upward and outward to a depth of 4–5 cm. (1⅝–2 inches). Usually the first tap succeeds. Leave the needle in place during the rest of the exploration.

It is now safe to open the dura. "Care must be taken in crossing the median line, for the sagittal cerebellar sinus may be of considerable size and

the cerebellar falx may penetrate in some cases for a considerable distance. As the midline is crossed the cerebellum should be held away with a spoon spatula, and the sinus may be caught, before division, with silver clips. Stellate incisions of the membrane to the margin of the bone defect are then made and the hemispheres fully exposed."

FIG. 30.—Showing denudation of suboccipital region: exposure of foraminal field by reflection of flaps: primary bone openings. (*Cushing*, "Tumors of Nervus Acusticus.")

When decompression is alone the object sought, the wound may now be closed. If there is any doubt of the diagnosis, compare the two hemispheres for differences of tension, of form, or of vascularity. "An intracerebellar cyst can usually be detected by palpation; an involvement of one hemisphere rather than the other by displacement of midline structures." If it is believed that a cerebello-pontile angle lesion is present, slight pressure with a spoon spatula

on the cerebellar hemisphere (Fig. 31) gives access to the region, provided that the margin of the mastoid has been included in the cranial defect.

The sigmoid sinus is first brought into view and at a varying distance beyond it, the arachnoid attachment or an encysted collection of fluid within the arachnoid, is ecountered. On opening the cyst the surface of the tumor

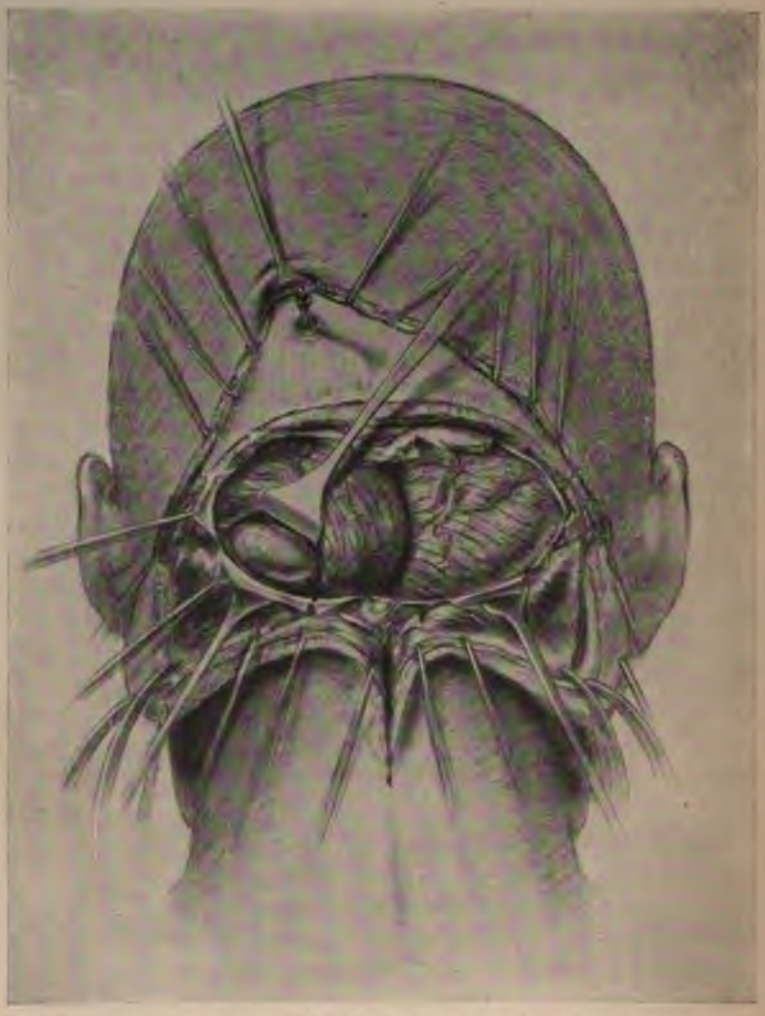


FIG. 31.—Showing exposure of encysted fluid within the arachnoid overlying a tumor, from a sketch during operation. (*Cushing*, "Tumors of Nervus Acusticus.")

will usually be seen. The best line of approach is toward the jugular foramen rather than directly toward the porus. With wet cotton pledgets wipe the arachnoid and the margin of the cerebellum from the tumor. The cerebellum must be protected continuously by a covering of wet cotton. Do *not* endeavor to extirpate the tumor, incise it bluntly and enucleate as much as possible intra-capsularly with a spoon like a gall-stone scoop. If there is much bleeding

insert pledgets of cotton wet with Zenker's solution. When the deep cavity is absolutely dry, allow the dislocated cerebellar lobe to settle back in place.

Closure of the Wound.—Close the vertical wound accurately with many interrupted sutures of fine silk. The four guiding clamps applied early in the operation aid much in assuring accuracy. This closure is made in several layers. Close the transverse wound by suturing the muscle, the fascia, the galea and the skin each separately. Apply temporary dressings and leave the patient on the table until conscious. Then put on voluminous dressings held in place by a starch bandage (wet crinoline bandage). Leave the dressing in place about 10 days.

Anton suggested that in cases of inoperable or unlocalized brain lesions (tumors, internal hydrocephalus, etc.) intracranial pressure might be lowered by perforating the corpus callosum, whereby a free communication would be established between the ventricles and the subdural space. If the intraventricular pressure is above normal the fluid must flow out into the subdural space and in doing so keep the perforation patent. Experiments made by Rehn show that such a flow does take place. The anterior and middle thirds of the corpus callosum form the best site for puncture as it is thinnest here and one or other of the lateral ventricles is sure to be penetrated. A careful study of callosal puncture has been made by v. Bramann ("Archiv für klin. Chir.," xc, 689), who operates in the following manner:

1. Choose a spot about one finger-breadth behind the bregma (1 to 1½ cm. behind the coronary suture) and expose the skull here by any suitable incision.

2. With a bur make an opening 1 cm. by 1½ to 2 cm. through the skull at right angles to the sagittal suture.

3. Note the longitudinal sinus and at its margin make a small opening through the dura mater.

4. Pass a sinus forceps (v. Bramann uses a special pliable silver cannula with a mandrin) alongside the sinus into the longitudinal fissure where it meets the falx. Guided by the falx, pass the instrument vertically downwards until it penetrates the corpus callosum.

5. Open the blades of the forceps (or remove the mandrin from the cannula) and permit the ventricular fluid to escape. Enlarge the callosal opening by moving the instrument gently backwards and forwards (not laterally).

6. Remove the instrument and close the wound in the scalp.

v. Bramann has performed callosal puncture in twenty-two patients without a death attributed to the operation (cerebral tumors thirteen; hydrocephalus eight; epilepsy one).

Anton and v. Bramann believe callosal puncture indicated: 1. In all cases of hydrocephalus where internal treatment has failed.

2. In all cases of tumors and pseudo tumors of the brain accompanied by internal hydrocephalus and choked disc which threatens blindness.

3. When intracranial pressure is so great as to interfere with palpation of the brain or with the removal of tumors, preliminary callosal puncture may aid.

OPERATIONS FOR INFECTIVE DISEASE OF THE MIDDLE EAR AND CRANIAL CONTENTS

Cerebral abscess is almost always the result of chronic otitis media. Proper treatment of the cerebral abscess requires removal of the original focus of disease. In the following pages the author makes free use of Macewen's classical work on the "Pyogenic Infective Diseases of the Brain and Spinal Cord." The reader is advised to carefully study the above book before attempting any operation for cerebral abscess. The present chapter is only written in the hope of aiding some parctitioner who is forced to operate without the advantage of such study.

Suppurative disease of the middle ear unrelieved by treatment administered through the external meatus is always complicated by disease of the mastoid. The chief indications demanding operation on the mastoid cells are:

1. Repeated inflammations of the mastoid antrum and cells with swelling over or fistulæ leading into the bone.

2. Acute inflammation with retention of pus in the antrum or cells.

3. The occurrence of initial symptoms of intracranial involvement associated with chronic purulent otorrhœa.

4. Persistent chronic otorrhœa, not principally due to the condition of the tympanum or Eustachian tube, and which is considered by the aurist otherwise incurable, even although there are no clear indications of mastoid involvement.

5. If the discharge contain virulent organisms, if it be highly offensive, mixed with osseous débris or cholesteatomatous masses, operation is indicated, as most serious intracranial mischief is often present without marked mastoid swelling.

The Operation.—I. Cleanse the external and middle ear as thoroughly as possible. Shave the scalp above and behind the mastoid. Cleanse the skin.

Step 1.—Place the patient on his side with the affected mastoid uppermost. Have the parts well lighted. Pull forward the external ear. Palpate the mastoid and the posterior root of the zygoma. Make a perpendicular cut about one-quarter inch behind the posterior border of the external bony meatus from the posterior root of the zygoma to a point about one-third of an inch from the tip of the mastoid. The knife penetrates to the bone. With the elevator separate the periosteum and soft structures from the bone in front of the cut and thus fully expose the posterior aspect of the external audority meatus. Attend to hemostasis. Hold the reflected tissues and auricle forward with a sharp retractor.

Step 2.—Observe the limits of the suprameatal triangle, viz., the posterior root of the zygoma above, the upper and posterior segment of the bony external meatus below, and an imaginary vertical line (EF, Fig. 32), extending from the most posterior portion of the external osseous meatus to the zygomatic root, behind. This vertical imaginary line is the base of the triangle. Observe the degree of obliquity of the posterior wall of the external auditory meatus as it leads inwards and forwards to the middle ear. By the aid of a probe observe the depth of the inner wall of the tympanic cavity from the level of the skull.

The best instrument for use in penetrating the bone is a bur rapidly rotated

by a surgical engine. One may conveniently use a bur operated by the "brace" shown in Fig. 13. Apply the bur to the bone at a point inside and beside the base of the suprameatal triangle. Penetrate the outer shell of hard bone. In some cases the whole mastoid is thickened and sclerosed by disease. With the bur, slowly and cautiously advance through the bone in a direction inwards and a little forwards, parallel to the posterior wall of the external auditory meatus. Do *not* use the bur as if it were a drill, making a uniform cylindrical perforation the same size as the instrument; this would be dangerous and nearly useless. Use it to make a hole in the mastoid very much larger than the instrument—large enough to permit of the continuance of the work under the guidance of the eye as well as of touch. The external opening may safely be made the whole size of the suprameatal triangle. Whenever a dark spot is seen on the cut

FIG. 32.—C, F, E (×). Suprameatal or Macewen's triangle.
A, B. Upper two-thirds of this line overlies the sigmoid sinus. C, D. Overlies sigmoid sinus from knee to commencement.

surface of bone, examine it at once with a fine probe or searcher (a dental probe is good). The dark spot is probably an opening into one of the mastoid cells or even the antrum; if the latter, the probe will find a large cavity communicating with the middle ear. The depth of the antrum from the surface varies from ⅛ to ¾ inch. A small opening having been made in the antrum and its cavity explored with a probe, bur away all its external wall, remove all pus, granulation tissue, or other disease products.

II. Observe the position of the opening between the antrum and the middle ear, the position of the facial nerve traversing the inner half of the floor of the antral passage obliquely from without inwards, as it passes into the inner wall and roof of the tympanum above the foramen ovale. The nerve route is often indicated by a cylindrical ridge of bone smoother and denser than that in the neighborhood. If the position of the nerve is not positively made out, have an assistant observe the patient's face for the occurrence of twitchings if the nerve is endangered in the subsequent proceedings. In observing the condition of the tissues deep down in the wound light should be thrown in, either by means

of a head mirror or of an electric lamp (with reflector) held by an *aid*. Examine the roof of the antrum for evidences of bone disease. If buds of granulation tissue sprout from the roof, examine them; they may come from inside the skull and show the presence and location of intracranial involvement.

Step 3.—Examine the mastoid cells opened during exposure of the antrum; if they are diseased, as evidenced by the presence of granulation tissue, pus, etc., destroy their walls with the bur, so that instead of numerous, irregular, small cells, one large cavity with smooth walls is formed. Remember the location of the sigmoid groove and sinus (Figs. 32 and 34). Because of the sinus it is wise to open the mastoid cells by working from the antrum downwards and backwards. Never attack an exposed cell before thoroughly exploring it with a probe. Remember that granulation tissue and other disease products may be continuous from the middle ear through the antrum, mastoid cells, sigmoid groove, and sinus to the cerebellum. If granulations are found sprouting out from the sigmoid groove or other evidences show disease in that locality, do not yet attack it. Complete the thorough cleansing of the antrum and mastoid, bur away all partitions, and leave them as one cavity with smooth walls.

Step 4.—The middle ear is diseased and requires to be opened. Apply a small bur at the junction of its roof with the outer wall of the antral passage. Do *not* touch the floor or inner wall of the passage for fear of injury to the facial nerve or semicircular canal. Freely expose the tympanic attic and examine its roof in the same way as the roof of the antrum was examined. Examine the malleus and incus; if diseased, remove them. It is important to leave the stapes, if possible; but if diseased, it also must be removed. If the mastoid antrum, and middle ear are the only seats of disease, the active operation is ended; the cavity is packed with iodoform and boracic acid (1:4) and with iodoform gauze. Closure of the wound is facilitated by removal of a portion of the posterior bony wall of the external auditory meatus. Dressings are applied.

Step 5.—If on examination of the roof of the antrum or tympanic cavity erosions of the bone exist and granulations sprout out from the cranial cavity, or if there are symptoms of intracranial involvement, active operation is continued. With the bur remove the eroded bone of the antral or tympanic roof in a direction outwards from the perforation. If pus and granulation tissue present, there is an extradural focus which must be carefully cleansed. Do *not* inject any fluids until the whole space between the dura and bone has been explored and the presence or absence of openings through the dura made certain. If there is no dural opening, gentle washing is safe, and the extradural space may be dressed with iodoform and boracic acid and iodoform gauze. If there is evidence of disease under the dura, clean the extradural space and freely open the dura.

Step 6.—Pus in the arachnoid or pia or on the surface of the brain must be gently washed away, and iodoform and boracic acid powder must be applied. If an abscess exists in the temporo-sphenoidal lobe, enlarge the opening through the roof of the antrum and tympanic cavity, apply iodoform and boracic acid to the wound, and proceed to Step 7.

Step 7.—Extend the cut through the soft parts upwards and expose the skull above the ear. Open the skull with a small trephine whose centre pin is

applied at a point three-fourths of an inch above the posterior root of the zygoma and in line with the posterior osseous wall of the external auditory meatus. Rub iodoform into the cut surface of the bone. Incise the dura. If necessary, make a crucial incision. Stop bleeding. If the abscess is large, the brain will probably bulge and fail to pulsate; if smaller, neither of these signs may be present. To explore for pus use a trocar and cannula or a sinus forceps. A hollow needle is liable to become plugged. Introduce the instruments inwards, downwards, and slightly forwards, so as to impinge, if pushed far enough, against the cranial aspect of the roof of the tympanum. If a trocar and cannula are used, the trocar should be removed at every quarter inch of progress to see if pus escapes; if a sinus forceps, the blades should be slightly opened for the same purpose. After pus is found, remember that the abscess probably contains sloughs and shreds of tissue too large to escape through the cannula and which must be removed. Alongside the cannula introduce closed, narrow-bladed hemostatic or sinus forceps; open the blades gently and permit the sloughs to flow out between the blades. If the sloughs cannot escape by themselves, they may be assisted out by forceps or spoon; their removal is of prime importance. After removal of the sloughs replace the hemostatic forceps by a small cannula. Through the mastoid wound and the opening through the antral roof introduce into the abscess cavity a cannula at least one-half as large again as that already *in situ*. Be sure that the end of this tube is in the cavity. It is wise to let the two cannulæ come in contact. Gently introduce a stream of hot water or mild antiseptic solution through the smaller tube and see that it all escapes through the larger. Lest fluid should enter the Eustachian tube, fill the middle ear with the iodoform and boracic powder. In an acute abscess which has been thoroughly cleansed of infective matter, a drainage-tube is of little value and may do harm. If there is doubt as to the thoroughness of the evacuation, introduce a decalcified bone drain so that its opening is just within the abscess. Stitch the drain to the skin. If the abscess cannot be properly drained, in the above manner, use a rubber or glass tube for from twenty-four to forty-eight hours. Treat the mastoid opening as already described. Close the temporal opening with or without drainage on ordinary surgical principles.

[If abscess of the temporo-sphenoidal lobe exists, without indication of disease requiring the mastoid to be opened, the operation is carried out practically as described in Step 7; but in washing out the abscess an escape for the fluid must be provided by means of a cannula, at least half as large again as that through which it enters. The two cannulæ lie side by side.]

Step 8.—It has already (Step 3) been shown that disease of the sigmoid groove may be discovered while the mastoid cells are being obliterated. Examination with the fine probe or searcher shows that buds of granulation tissue coming through osseous openings are continuous with the same tissue in the sigmoid groove. Apply the bur to the posterior wall of the antrum and with it remove the bone horizontally backwards for half an inch. In a majority of cases this will open the greater part of the diameter of the sigmoid groove after which it may be opened above and below that point as may be indicated. The anterior knee of the sinus is situated from one-eighth to a quarter of an inch behind the base line of the suprameatal triangle (Fig. 32). If it seems

necessary to open the sigmoid sinus to remove septic blood-clot, fully one inch of the sinus ought to be exposed, vertically, by removal of bone. Remove any diseased tissue lying between the groove and the sinus. If, on examination by the eye and the probe, the disease is found to extend through the bone into the cerebellum, this disease route must be followed and cleansed and any cerebellar abscess attended to in the manner to be described. If there is septic sinus thrombosis, open the sinus and remove the filth within it. After cleansing the sinus, introduce into it a quantity of iodoform and boracic acid powder, make the walls of the sinus collapse, gently pack the sigmoid groove with the same powder, and loosely pack the whole cavity with iodoform gauze. If during the operation hemorrhage take place from a non-thrombosed sinus, it may be stopped, if slight, by temporary pressure; if more severe, by separating the wall of the sinus from the bone and pushing the loosened wall inwards by means of iodoform gauze packing. In certain cases Horsley has found it valuable to doubly ligate and divide the internal jugular vein. This is intended to prevent dissemination of the infective material throughout the body.

Step 9.—In the preceding step it has been shown how extension of disease through the sigmoid sinus to the cerebellum may be discovered. If this is the case, the disease is followed and the bone between the sigmoid groove (outer aspect of the groove) and the cerebellum is removed by the bur. The membranes covering the cerebellum are treated in the same manner as were those covering the temporo-sphenoidal lobe. If a cerebellar abscess exist, enlargement of the osseous opening already made permits of its evacuation and treatment on the principles already described.

After-treatment.—If there is no evidence of petrous or internal ear disease, the wounds must be packed with iodoform gauze to compel healing to take place from the bottom. The whole cavity ultimately becomes a solid mass of scar tissue. In the presence of petrous or internal ear disease a seton of iodoform gauze must be passed from the middle ear, through the antrum out by the mastoid opening. This gauze seton is frequently renewed and its route kept clean, until epithelium from the mucous membrane and the skin has so covered the track that a permanent fistula is assured through which any discharge from the internal ear or petrous bone may escape. The formation of the permanent sinus may be hastened by lining it with skin grafts.

After the dressings are applied put the patient to bed, and keep him there until the wounds are completely healed. A low liquid diet is recommended for a fortnight after cerebral abscesses have been evacuated. The only peculiarity of the after-treatment is the necessity of a little extra insistence on quiet, and on the observance of the usual rules adopted after major surgical operations. It is well to have the room darkened.

Abscesses in other localities of the brain, after being diagnosed and located, are operated upon on the same principles as have been described in the preceding pages.

OPENING THE MASTOID WITH THE CHISEL AND RONGEURS

Undoubtedly the bur operated by a surgical engine is the most elegant instrument with which to open the mastoid antrum, and it possesses many advan-

tages over the chisel; but comparatively few surgeons possess the necessary instruments nor are they convenient to carry to a patient's home when the patient cannot or will not enter a hospital. Most surgeons possess some dexterity in the use of the chisel but are not educated to the bur, hence the chisel and its relative, the rongeur forceps, are the instruments commonly used in the mastoid operation.

The operation often ends immediately after the mastoid antrum is opened. This is improper, as the antrum is only one of many mastoid spaces, any or all of which may be diseased.

Whiting ("The Modern Mastoid Operation"), in his superbly illustrated book, shows how the "air-cells" may extend above and over the bony meatus, and unless these are obliterated, the suppurative process is sure to continue. The principle of the complete operation on the mastoid is the obliteration of *all* the mastoid cells and the removal of all disease wherever situated, as described in the preceding pages. The method of operating usually adopted by the author is much as follows:

Clean the ear as well as possible. Shave and clean the skin over and around the mastoid.

Step 1.—Make an incision parallel to the insertion of the auricle and about ¼ inch posterior to the external auditory meatus. The incision stretches from just above the root of the zygoma to a little below the tip of the mastoid. Expose the whole surface of the mastoid by reflecting the soft parts along with the periosteum. A second incision at right angles to the first may be necessary to insure exposure. Examine the bone for points of necrosis or for the escape of pus at the vascular orifices.

It is especially important to examine the mastoid vein at its outlet, which is usually near the posterior margin of the bone. The vein varies in size and may divide into several branches as it passes through the skull. As the vein communicates directly with the sigmoid sinus, when the latter is thrombosed the former is likely to be in the same state. Thrombosis of the mastoid vein is positive evidence of sinus thrombosis; apparent patency of the vein is of no significance. Pus oozing from the mastoid foramen signifies pus situated outside the dura in the cerebellar fossa, about the sigmoid groove.

Step 2.—Pull the external ear well forwards with a retractor. Observe the depth and direction of the external auditory canal. Beginning at the upper part of the suprameatal triangle, shave off *thin* slices of bone downwards and forwards towards the tip of the mastoid, always hugging the posterior margin of the bony meatus. This shaving is to be done with a chisel or gouge about ¼ inch in width, propelled by a mallet. The chisel must be held almost parallel to the surface of the bone, and must always be directed downwards and forwards.

The usual chisels and gouges supplied for mastoid work are short and have thin shanks and handles. Such may be safe and convenient in the hands of aurists, but to the general surgeon a chisel with a handle like a Macewen osteotome, or even a carpenter's tool, is much safer and more practical. It is well to have a number of chisels or gouges of different sizes.

After several exceedingly thin slices of bone have been removed, the diploë will be reached, unless there is much sclerosis.

With a narrow curette scrape away the superficial portion of the diploë. If pus or fluid appears, note its quantity, as this gives some index to the size of the cavity from which it comes; note also if the pus is thrown out in jets or pulsating fashion, because such pulsation is communicated from the brain and is almost absolute proof that the disease has penetrated at least to the meninges. With a probe gently explore the pus-cavity and enlarge the opening with curette, gouge, or rongeur, as may be convenient. *Never* endeavor to clean out a pus-cavity in the mastoid with the curette through a narrow external opening—it is too dangerous. If no pus or fluid appears, deepen the groove already cut in the bone to the extent of ⅓ inch. If the sigmoid sinus is abnormally far forwards, it ought now to be visible as "a soft, bluish-looking structure, very fluctuant to palpation and perhaps pulsating demonstrably, which upon gentle pressure of a probe yields readily but does not bleed" (Whiting). When the sinus is found in this abnormal position, the rest of the operation consists in exposing all the diseased cavities and evacuating all infective material, without injuring the sinus, unless that structure is involved in the process. When the sinus is not abnormally placed, proceed with the removal of all the outer wall of the mastoid process.

FIG. 33.—Narrow-bladed rongeur forceps.

Step 3.—With the chisel repeat the manœuvres by which the mastoid was originally opened, and so widen the existing opening that the blade of a rongeur (Fig. 33) can easily enter it and pass under the bone. With a rongeur carefully bite away the whole bony outer wall of the mastoid process. Never attack any part of the bone before making sure that the sigmoid sinus will not be injured.

Instead of widening the original opening in the bone with the chisel, the author usually inserts into it, partially, one blade of a heavy rongeur, the other blade of which rests against the mastoid farther back. By exerting a twisting force it is easy to use the posterior blade of the forceps as a fulcrum, and with the anterior blade (the blade engaged in the bony opening) to scrape off a thin layer of the cortical bone. This method of using the rongeur is difficult to describe, easy and safe to practice, and aids materially in the operation. When the mastoid has once been opened to such an extent that the ronguer can be used efficiently, either as a biting or as a scraping instrument, put the chisel and mallet aside as of no further use. If much sclerosis is present, this rule does not apply.

Step 4.—No attempt has been made, as yet, to find the antrum or systematically to obliterate the mastoid cells; the cortical bone has been removed, at least to a large extent; the diploë has been but little disturbed. Remember that the antrum in 99 per cent. of cases (Macewen) lies in whole or in part within the suprameatal triangle; that in the adult its depth beneath the cortical bone varies from one-eighth to three-fourths of an inch.

With a probe, once more observe the direction and depth of the bony meatus.

With the curette, cautiously remove the cancellous bone from the suprameatal triangle in a direction parallel to the posterior wall of the bony meatus. This will almost inevitably open the antrum. If the bone is much sclerosed, a small gouge must be used instead of the curette. Having opened the antrum, explore it thoroughly with a probe. With the curette, aided, if necessary, by rongeur forceps, remove all the external wall of the antrum. In the same manner remove *all* the mastoid air-spaces. Every step in the removal of bone must be preceded by careful examination of the tissues to be removed; remember particularly the normal site of the facial nerve (Fig. 34) and the normal, and particularly the abnormal, course of the sigmoid sinus.

FIG. 34.—Left temporal bone.
Antrum and most of the mastoid cells obliterated. 1. Semicircular canals. 2. Location of facial nerve in aqueduct of Fallopius, which has been opened. 3. Location of sigmoid sinus.

The mastoid has now been converted into a comparatively shallow pit. Examine the walls of the pit carefully to see whether the disease process does or does not penetrate the cranial cavity. If the disease involves the sigmoid sinus or the meninges elsewhere, it must be attacked according to the principles already enunciated.

In *acute* mastoiditis, after the antrum, etc., have been cleaned out, the inflammation of the tympanum will promptly recede; hence it is unnecessary to use the curette in the tympanic cavity (Whiting). This is fortunate, as otherwise much damage to hearing might easily be inflicted. In cases of chronic mastoiditis and otitis the tympanum must be thoroughly opened and appropriately treated along the lines laid down on page 36 *et seq.*

Step 5.—With rongeur forceps and curette make smooth the floor and sides of the bony defect. Partially close the wound in the soft parts with sutures. Pack the remainder of the wound with iodoform gauze. It is comforting to the patient to have the gauze separated from the wound by a layer of perforated

oiled silk or rubber tissue. After granulations have formed along the course of the pack they may be covered by Thiersch's skin-grafts. This is usually two or three weeks after the operation.

It must be remembered that in children under three years of age the mastoid process is either absent or its presence is merely indicated, while the antrum is to be sought rather higher than in the adult. In these young children the bone is so soft that the antrum may be opened with a curette.

In cases of acute (not chronic) mastoiditis Stenger makes a short incision over the mastoid, reflects the periosteum and, if no fistula is present, chisels or bores a narrow passage towards the antrum. He curettes this passage (which need not penetrate the antrum) or the fistula, if such is present, and loosely packs with gauze, dries the surrounding skin and applies a cupping glass provided with some form of pump for suction. A sterile ointment spread on the skin makes the cupping glass act better. The suction is kept up not longer than three hours at a time. The suction causes pain while it acts, but the relief is great during the intervals. Stenger and Hasslauer report excellent results and a shortening of convalescence. ("Muenchner med. Wochensch.," Aug. 21, 1906.)

The use of suction by means of the cup undoubtedly may help drainage, but its main object is to obtain hyperemia and the whole procedure is based on the ideas of Bier.

OPERATIVE TREATMENT OF MENINGOCELE AND ENCEPHALOCELE

Operation should not be undertaken in cases of the above tumors when there are serious concomitant malformations or when it is believed that portions of brain, necessary to life, are present in the growth. Horsley has suggested the application of the induced current to the tumor in order to diagnose if important cerebral tissue is involved. Some surgeons—*e.g.*, Berger—believe, and act on the belief, that any cerebral material present in a meningocele is neoplastic in nature and possesses no physiological function and may safely be disregarded. With the exceptions mentioned above, Chipault considers all cases of meningocele suitable for operation. [Meningoceles of the cranial vault are alone referred to at present.]

The Operation.—Trace out two flaps of skin alone, over the tumor. The base of each flap corresponds to the pedicle of the tumor. Reflect the flaps. Expose the pedicle of the tumor at its exit from the skull. Transfix the pedicle, with a blunt needle, close to the skull, in one or more places, and apply two or more interlocked catgut ligatures. Tie the ligatures. Cut away the tumor distal to the ligatures. Replace the skin-flaps. Suture. Dress. Instead of ligating the pedicle as above described, it is better to open and explore the sac. If brain tissue is present, looks normal in character, and is reducible without giving rise to symptoms of compression, reduce such brain tissue, excise the rest of the tumor, and close the opening in the cerebral membranes with suture. If no brain tissue is present, excise the sac. If brain tissue is present but is either abnormal in appearance or irreducible, it must be excised. From the

literature of nine years Chipault collected fifty cases of meningocele subjected to operation with only nine deaths.

Meningoceles protruding through the base of the skull are rarely in situations accessible to the surgeon. In one case Fenger gained access to the tumor by temporarily resecting the superior maxilla, and saved his patient. When it is possible to expose a basal meningocele the principles of operation are the same as those already described.

MICROCEPHALUS. IDIOCY

Lane, Fuller, and Lannelongue advised removal of portions of the skull in cases of microcephalus, on the supposition that the early closure of the skull and consequent defective bone cavity, impeded cerebral development. Variously shaped portions or strips of skull have been removed by many surgeons and the primary results seemed promising. The author in several cases was astounded to find, even on the day following operation, marked improvement in the condition of such patients. The improvements in speech and mentality were truly incredible, but in not one of the cases observed by him were these improvements retained, and he is forced to conclude that such operations are worthless. They will not be described here.

HYDROCEPHALUS

The earliest attempts to treat hydrocephalus by surgical means consisted in the application of strapping to the head in the endeavor to prevent its increase in size or to diminish its size. Such means were doomed to failure. Later, paracentesis was resorted to, and cerebrospinal fluid was removed in greater or less quantity, but though repeated paracentesis occasionally gave relief yet sooner or later meningitis generally developed and death ensued.

Mikulicz suggested draining the cerebrospinal fluid into the tissues under the scalp and this procedure was carried out in several different ways. Metal tubes were inserted so as to conduct fluids from the ventricles to the subcutaneous tissues. Silk threads, formalinized arteries or veins were used for the same purpose but, as is noted elsewhere, while temporary success was not infrequent, the subcutaneous tissues refused to continue acting as absorbents and permanent good results were notable because of their absence.

Leonard Hill (quoted by Cheyne and Burghard) has shown that the amount of cerebrospinal fluid is regulated by absorption and exudation from the veins or lymphatics of the brain, more especially towards the base; and if any cause interferes with the normal regulation of this cerebrospinal fluid the result on the brain will be very serious. Meningitis interferes with this regulation, so that the fluid collects in the ventricles and causes hydrocephalus. See also W. E. Dandy, Diagn. & Treatment Hydrocephaly resulting from Stricture of Aqueduct of Sylvius, Surg. Gyn. and Obst., Oct. 1920.) The meningitis at fault is specially present at the base of the brain near the fourth ventricle, obstructing the exit of fluid from the ventricles, and hence its proper absorption. Based

on the above, G. A. Sutherland and one of the authors referred to, attempted to establish the natural absorption by the following operation:

Reflect a flap of scalp and open the skull near and posterior to the anterior fontanelle (occasionally the lower angle of the fontanelle itself has been opened). Incise the dura. Take about twelve strands of thin catgut 2 to 3 inches in length and tie the ends together. Pass one end of this bunch of catgut downwards and backwards between the brain and the dura until about ¾ inch is left projecting from the opening in the dura. Seize the free end of this projecting portion in a forceps and push it through the brain into the lateral ventricle. Thus a catgut drain is made to stretch from the ventricle into the subdural space. Close the wound in the dura and the scalp. As a rule, the temperature runs up to 104° or 105°F., but falls again in the course of a week or ten days. The skull soon diminishes in size to a very marked degree.

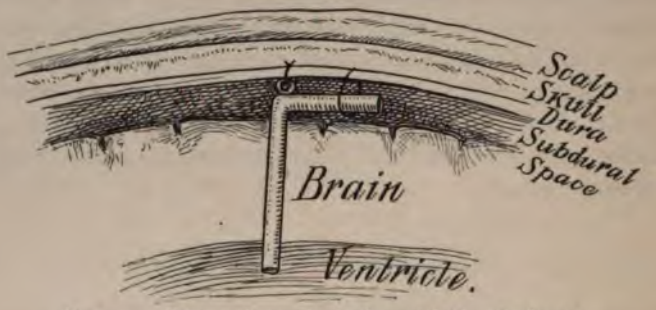


FIG. 35.—Ballance's method of ventricular drainage.

The results have been better in congenital than in acquired hydrocephalus; in the latter it has been extremely difficult to keep up a channel of communication between the ventricles and the subdural space, and it has been suggested to use a more resistant form of drain. In spite of the success attained, the patients have generally succumbed, after a few months, to progressive meningitis.

Ballance ("Am. Surg. Assoc.," 1906) finds the thread drainage insufficient, therefore he uses a fine Γ-shaped tube of pure platinum or of gold and iridium (pure gold is too soft). One limb of the tube is provided with a small ring or loop near the angle. One leg of the tube is made to penetrate the ventricle, the other leg lies between the brain and the dura, being fixed to the latter by sutures (Fig. 35).

Ballance has had a number of complete recoveries from hydrocephalus following ligation of both common carotid arteries at an interval of about ten days. In these cases there is no special danger from shutting off both common carotids.

v. Bramann endeavors to attain the same end by means of puncture of the corpus callosum (see p. 33).

The blood pressure in the cerebral tissues being very low Payr conceived the idea that it would be possible to drain cerebrospinal fluid directly into the longitudinal sinus. As an aqueduct from the lateral ventricle to the sinus a tube lined with endothelium and provided with valves to prevent reflux of blood

is desirable. Such a vein as the great saphenous, if transplanted, is calculated to fulfill the requirements.

Payr's Operation ("Archiv für klin. Chir.," lxxxvii, Hft. 4).

1. Make a transverse **U**-shaped flap consisting of skin periosteum and bone as shown in Fig. 36. The convexity of the flap is on the side to be drained and its pedicle, 2 to 3 cm. wide, is at least one finger's breadth to the opposite side of the mid-line. Reflect the flap.

2. On each side of the longitudinal sinus elevate a **U**-shaped flap of dura having its base towards the sinus.

3. With an exploring needle of small size and having a scale marked in ½ cms. on it, puncture the lateral ventricle at a spot not far from the longitudinal fissure and drain off slowly a small quantity of fluid and at the same time note the depth of the ventricle from the surface. Remove the exploring needle—it has served its purpose of relieving tension and showing the distance of the ventricle from the surface.

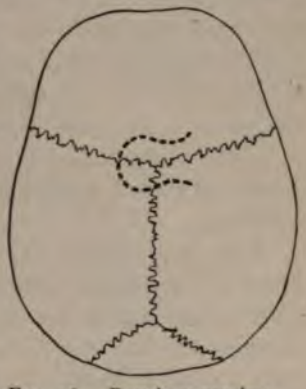


FIG. 36.—Payr's operation. (*Payr.*)

4. Have an assistant make an incision over the long saphenous vein and by sharp dissection remove a segment of it. There must be no bruising of the vein. The length of the vein requisite must be from 50 per cent. to 60 per cent. longer than the distance from the longitudinal sinus to the ventricle as the excised vein shrinks very markedly. When excised place the vein on gauze soaked in warm salt solution and keep it warm. Note and remember which is the proximal end of the vein as that is the end which must be sutured to the sinus in order to take advantage of the valves in the vein.

5. Penetrate the ventricle with an aluminum trocar (2 to 3 to 4 mm. in diameter) which has a ½ cm. scale marked on it. Permit the fluid to escape very slowly; a plug of cotton in the trocar permits the fluid to escape in drops.

6. At least 2 to 3 cm. of the longitudinal sinus is exposed. Lift up the two dural flaps made in Step 2. This permits one to see the falx under the sinus. With semiblunt needles threaded with thin elastic or with a thin rubber tube perforate the falx anteriorly and posteriorly to the exposed segment of sinus. In this manner an elastic band goes from side to side under the sinus—one in front and one behind the site of proposed anastomosis—and when fixed by a stitch to the scalp on each side of the sinus these exercise pressure on the sinus and so stop the circulation temporarily.

7. To the right and to the left of the site chosen for anastomosis introduce and tie a suture of fine silk which penetrates only the external tunics of the sinus. Leave the ends of these sutures long. If bleeding takes place when the sinus is incised it can be promptly stopped by crossing the sutures.

8. Incise the sinus and introduce into it obliquely and backwards the proximal end of the excised long saphenous vein. It is wise to have the end of the vein folded back like a cuff so that any part of it which may protrude into

the sinus is covered with endothelium. With fine silk sutures fix the vein to the opening in the sinus and, as supporting sutures, tie together gently the two threads introduced in Step 7.

9. Remove the aluminum trocar from the ventricle and push the free end of the segment of vein along its course into the ventricle. This may be done with a stilet of stiff silver wire. It is well to have the end of the vein turned back on itself in cuff fashion.

10. Remove the elastic constrictors from the sinus. Close the dural wound. Close the cranial-scalp wound.

Several observers have noted that when drainage has been established between the ventricles or the meninges and the cellular tissues, absorption of the fluid was at first satisfactory but that later the cellular tissues refused to continue absorbing the fluid and encysted it instead. A. H. Ferguson drilled a hole through the body of the fifth lumbar vertebra and passed a silver wire through it from the spinal to the peritoneal cavity. Nicoll proposed the following steps: laminectomy; resection of a transverse process; insertion of a tube (decalcified bone, glass) from the spinal meninges to the peritoneum; instead of inserting a tube Nicoll has sutured a tag of omentum to the meninges.

Heile has sutured the meninges to the peritoneum of the large intestine. Harvey Cushing has endeavored to establish drainage between the meninges and the neighborhood of the peritoneum. The following is quoted from Cushing's article in Keen's Surgery: "It is essential in the first place to determine if possible where the obstruction lies, for if it is evident that the foramina of Magendie and Luschka are occluded, some method of direct ventricular drainage must be resorted to. As the *first step* a lumbar puncture is performed, the tension of the fluid is registered, and if an amount sufficient to demonstrate that it must come from the ventricle can be withdrawn, the needle is removed and the fluid analyzed.

"The *second step*, carried out some days later, is to determine whether the child will withstand the withdrawal of a large amount of fluid, for though I have never seen convulsions, collapse, etc., from this source, such accidents have been recorded by Keen and others. To do this, a combined puncture of the lumbar region and ventricle is performed. A long glass tube of small calibre connects, by a short rubber tube, with each needle, and the fluid, when lumbar or ventricular space has been entered, spurts up into the tube to its tension level, about which it fluctuates with the cardiac and respiratory rhythm. If the foramen of Magendie is open the fluid seeks the same level in both tubes, and when either of them is dropped and the fluid allowed to escape the level in the other falls. Thus, the ventricle may be emptied by either tube—rapidly by the ventricular, slowly by the lumbar—and I have withdrawn in this way from the lumbar subarachnoid space alone as much as a litre of fluid. The tubes are then withdrawn, the small scalp wound closed, dressed, and the fluid allowed to reaccumulate. A comparative chemical analysis of the fluid taken from the two sources should show them to be the same. When thus demonstrated that the ventricular fluid already communicates by natural channels with the subarachnoid space, it becomes evident that an additional operative communication

between ventricle and the subarachnoid spaces over the hemisphere is superfluous and unavailing. The indication is clear that one must find some other means of escape for the fluid, and I have attempted to drain into the retroperitoneal space as follows:

"*Third Step.*—It having become established (1) that the ventricle can be emptied by the lumbar route and (2) that the withdrawal of fluid is not prejudicial to the child's well-being, the following procedure, after an interval of some days, is carried out. A laparotomy is performed; the posterior layer of peritoneum to the left of the rectum is split; the body of the fifth lumbar vertebra just under the bifurcation of the vessels is exposed; the bone is trephined by a specially constructed small-calibre trephine, and one-half (the female portion) of a silver cannula, exactly the size of the trephine, is inserted and held in position. The child is then turned on its face and a laminectomy is performed; the subarachnoid space is opened, the strands of the cauda separated, and the

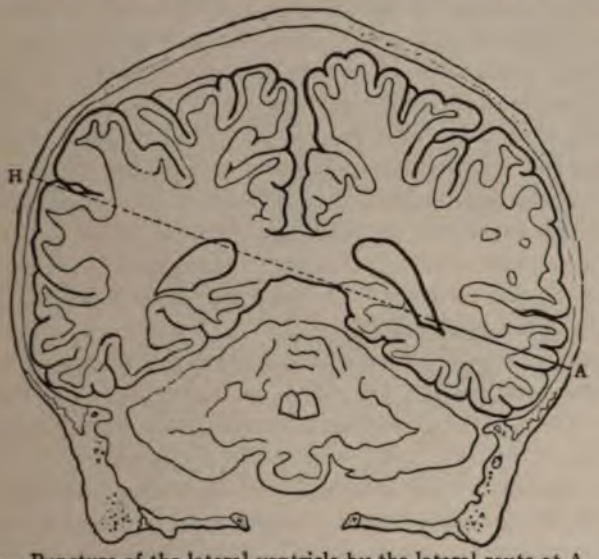


FIG. 37.—Puncture of the lateral ventricle by the lateral route at A. (*Keen, Am. Text-Book of Surg.*)

posterior half (male portion) of the cannula is invaginated, so that it locks into the portion inserted anteriorly. Both wounds are then closed. The fluid for a time finds its way into the peritoneal cavity, but ultimately only into the retroperitoneal space, whence it is taken up by the receptaculum chyli, as experimental observations have shown. It can be seen that this combined lumbar method is especially desirable in cases of hydrocephalus complicated by spina bifida, a radical cure of which may be made in association with the posterior part of the operation. I have carried out this procedure, which is briefly recorded here for the first time, in twelve cases, with a considerable measure of success."

ACUTE HYDROCEPHALUS, DRAINAGE OF LATERAL VENTRICLE

Keen's Method.—(A) Choose a point 1¼ inches above the upper margin of the external auditory meatus and the same distance behind the meatus.

Open the skull at this point with a ½ inch trephine. On the opposite side of the head choose the point H (Fig. 37) 2½ to 3 inches above the meatus auditorius. Through the trephine opening pass a grooved director or fine cannula towards the point H. The cannula should reach the ventricle at a depth of 2 to 2¼ inches. If drainage is required introduce some threads of horse-hair or a fine tube of rubber.

OPERATIONS IN CASE OF EPILEPSY

I. Idiopathic Epilepsy.—(A) *Prophylactic Treatment.*—The report of results obtained in Körte's clinic (see p. 17) in cases of complicated fractures of the skull very strongly indicates the propriety of restoring the integrity of the skull after operations or fractures. The methods of doing this are discussed elsewhere (see p. 11).

Prophylactic treatment resolves itself essentially into the avoidance of local irritation and obtaining the most complete repair feasible.

(B) *Operative Treatment.*—The name idiopathic epilepsy is used as a cloak for ignorance and to denominate the non-focal forms of the disease. Many operations have been performed for the cure of the disease; the results have been good, bad and *nil;* negative results being the rule. The fact that many operations on regions apparently unconnected directly with the head have been followed by symptomatic cure of the disease led J. W. White to speak of "operations *per se*" being occasionally curative. Undoubtedly it is good practice to correct possible sources of irritation in epileptics, such as eye-strain, tight foreskin, decayed teeth, etc.

After shaving the head, scars will commonly be found on the scalp, even when no history of trauma has been elicited. Many of these scars are undoubtedly the result of accidents directly due to the epilepsy, but as undoubtedly, in occasional cases, one of the scars is the visible evidence of a trauma which occasioned the epilepsy. All such scars should be carefully examined as regards (*a*) tenderness to touch or to percussion, (*b*) mobility or adhesion, (*c*) condition of periosteum or bone, (*d*) the production of vasomotor or psychic symptoms on manipulation.

Keen is so strongly convinced that a scar of the scalp may be the cause of epilepsy that after having excised the scar and having found the bone without evidence of injury, he closes the wound and waits; if excising the scar fails to cure, he then—and not until then—considers the advisability of performing some other operation.

Friedrich, in traumatic epilepsy, chooses the site of trauma as the site for operation even when the "aura" would indicate some other location as the starting-point of the epileptic explosion.

Kocher, believing increased intracranial pressure to be the important etiologic factor in idiopathic epilepsy, trephines and excises the dura over the right fronto-parietal region, as a rule; to this he sometimes adds drainage of the lateral ventricle.

Friedrich's results ("Archiv für klin. Chir.," lxxvii, Hft. 3) in eight cases kept under observation for years after operation show one case cured of epi-

lepsy and coincident mental disturbances; two cases of very great improvement; one of improvement; one of temporary improvement; three unimproved.

If not guided by the evidences of old trauma Friedrich follows Kocher and operates over the posterior portion of the frontal lobes (right).

The operation is as follows:

Step 1.—Reflect a large flap of scalp, having its pedicle below. Open the skull and *excise* with forceps or other instruments a segment of bone. The size of the segment of bone removed varies from 20 to 48 sq. cm. (8 to 19 sq. in.).

Step 2.—Very carefully remove an area of dura varying in size from 9 to 33 sq. cm. (3½ to 13 sq. in.). Do *not* injure the subjacent pia. Avoid as far as possible all hemorrhage.

Step 3 —Replace the flap of scalp and suture. Apply dressings.

C. H. Mayo has had some success after operating as follows: Reflect a large osteoplastic flap; cut the fractured edges of the bone smooth. Reflect a flap of dura corresponding to the osseous defect. Push the dural flap into a pocket

FIG. 38.—C. H. Mayo's dural drainage.

between the scalp and the bone (Fig. 38). Replace the osteoplastic flap, the bone of which lies next to the pia arachnoid. The dural flap acts as a drain between the meninges and subcutaneous lymphatics. Cushing's decompressive operation may be employed.

Although all such operations are perfectly justifiable under proper conditions, yet the surgeon must not be too sanguine as to results. Almost any operation is frequently followed by a temporary cessation of epileptic seizures, but recurrence is the almost invariable rule. Jonnesco's method of sympathectomy cannot be considered of proved value.

II. Focal or Jacksonian Epilepsy.—In focal epilepsy the irritation seems to originate in some particular point on the surface of the brain and to radiate to other parts. The parts affected are those which have been mapped out in the study of cerebral localization. The causes of this condition are numerous. Depressed fracture, osteophytic growths, neoplasms, localized meningitis causing adhesions, hemorrhage, abscess, etc., are all efficient causes and ought to be removed or corrected. If no macroscopic lesion can be found when the skull is opened and the brain exposed, the precise area from which the attacks radiate

may be defined by means of stimulation by weak electrical currents. The gray matter of this area, plus the pia mater covering it, may be excised. Of course, excision of an area of cortex means paralysis of the regions controlled by this area, but the paralysis seldom remains permanent. Immediately after the operation there is often a very temporary paralysis of parts supplied by neighboring centres. A few good results have followed cortical excision, but the rule is that epilepsy recurs when healing takes place. If a scar is removed from the brain, another scar is necessarily formed in the process of repair. There is a great difference, however, between the scar resulting from a clean incision or excision and one resulting from a coarse trauma or from inflammation. Covering a cerebral wound with celluloid, goldfoil, or rubber tissue prevents adhesion between the brain, meninges, and scalp or skull, and is a useful precaution. An implant of fat may also be of service.

Carl Beck's Operation.—In some cases of epilepsy ("Annals of Surg.," Aug., 1906) due to adhesions at the site of a hiatus in the skull, the result of fracture or operation, Beck has obtained some good results by plugging the skull defect with temporal muscle and fascia, the fascia being placed next the brain or dura.

FIG. 38A.—Beck's operation for traumatic epilepsy.

The Operation: Step 1.—Make the ∩ incision ABC (Fig. 38A) and reflect the flap or scalp thus formed. This exposes the defect in skull. Carefully remove all scar tissue and exostoses from the defect and its surroundings. This means usually removal of dura. With chisel or rongeur remove enough bone from around the defect so that an edge of intact healthy dura is exposed. Attend to hemostasis.

Step 2.—Continue the incision BA to D and BC to E, and reflect the flap DFE. This flap must consist of scalp alone; the temporal fascia *must* be left intact.

Step 3.—Form the flap HKI consisting of temporal fascia, temporal muscle and pericranium, and having its pedicle towards the skull defect. This flap must be large enough to completely fill the defect. Turn the flap HKI upwards

and place it in the skull defect, the temporal fascia lying on the brain. Suture the temporal fascia to the dura.

Step 4.—Attend to hemostasis. Replace the flap DEF and fix it with sutures, providing for drainage, if necessary. Apply dressings.

In cases similar to those for which Beck devised his operation other surgeons reflect the scalp, remove scar tissue, etc., at the same time excising scars in the dura and freshening the edges of the bony hiatus. The usual methods of endeavoring to prevent fresh dural adhesions have been described elsewhere. Finsterer replaced destroyed dura with a portion of a hernial sac placed with its serous surface towards the brain. The sac, obtained during an operation for hernia, had been preserved in a 2 per cent. formol solution but was thoroughly washed in normal salt solution before use ("Beiträge z. klin Chir.," lxvii, 193). In experiments made on dogs Finsterer found that such peritoneal grafts preserved their vitality (?) and did not contract adhesion to the subjacent brain.

Perthes (German Surg. Congress, 1912) has used fresh hernial sac after Finsterer's method in seven cases, with success in six, and death in one due to infection secondary to a meningeal fistula.

Hanel ("Archiv für klin. Chir.," xc, 823), stimulated by Morris' recommendation of Cargile's membrane, prepared material from the intestines of sheep as follows: Bend a glass rod so as to make a four-sided frame; split open and stretch on the frame a segment of sheep's intestine. Soak in a 4 per cent. solution of formalin for twelve hours; wash in running water twelve hours; boil in water for ten minutes; preserve in the following solution: sublimate 0.8, glycerine 40.0, alcohol 800.0. Hanel used this material in the same manner as Finsterer uses hernial sac and Morris uses Cargile membrane. Hanel's membrane is absorbed after the lapse of about two or three weeks.

Kirschner ("Archiv für klin. Chir.," xcii, 894) recommends the use of fascia in covering dural defects. He obtains the material by excising a sufficiency of the fascia lata from the patient himself and after cutting away all fat from it places it over the dural defect and pushes its edges under the skull between the dura and the bone. At the German Surg. Congress, 1912, he reported seventeen cases from Körte's clinic. He writes: "(1) In all the cases the transplanted fascia healed without reaction.

"(2) In the cases where the implantation was made to replace dura pathologically affected in cortical epilepsy, there were no more convulsions." (Too short a time has elapsed to permit of final conclusions.)

"(3) When diseased dura was widely excised, water-tight closure of the subdural space was at once obtained by implantation of fascia. No meningeal fistulæ developed.

"(4) When operation is imperative in circumstances where the external wound cannot, with certainty, be rendered clean, the implantation of fascia hinders infection of the cerebrospinal fluid." (To the author this appears very dubious in view of the necessity of absolute asepsis when implanting any foreign material, even autoplastic.)

"(5) When much dura and bone are both removed the implanted dura prevents cerebral prolapse."

Lexer in a case of traumatic epilepsy, after excising an old scar uniting the meninges to the soft parts, implanted a free (non-pedunculated) flap of fat between the brain and the scalp. The result was very happy. In a case in which pain and giddiness resulted from adhesions between the meninges and scalp, the author followed Lexer's method and implanted a free flap of fat obtained from the patient's abdominal wall. The result was very satisfactory.

HEMORRHAGIC PACHYMENINGITIS

Bullard and John C. Munro have made strong pleas for the consideration of hemorrhagic pachymeningitis as a surgical condition demanding operation. The disease, when not found in infants or the insane, is one belonging to the later years of life. Alcoholism, syphilis, acute and wasting diseases, as well as trauma, seem to have some causal relation to the disease. The symptoms are those of diffuse subdural hemorrhage, coming on slowly, producing mental irritation, spasm, paralysis, the sequences being more or less irregular. The cranial nerves are not liable to be affected. Without relief by operation the prognosis is practically hopeless; with operation, it is still very poor but better than without. One of Munro's cases recovered; it was that of an alcoholic sixty-two years of age, picked up on the streets unconscious. On admission to hospital he could not be roused. There was no bleeding from the mouth, nose, or ears. Temperature was normal, pulse 80; right knee-jerk absent; no rigidity; hematoma in right parietal region. Trephined on right side; no pulsation of dura, which was bulging and dark blue. Subdural clot covering the whole hemisphere removed. Trephined on left side; a diffuse, thin clot was found and removed. Towards the close of the operation consciousness returned. The result was complete recovery. In another case failure to trephine on both sides led to death, though immediate improvement followed the operation.

HYPOPHYSECTOMY

Attempts have been made to cure or relieve patients suffering from hyperpituitarism (acromegaly) and hypopituitarism by excising the hypophysis (pituitary body) either completely or incompletely. The pituitary body lying as it does in the *sella turcica* may be approached from above and the side through the cranial cavity or from in front and below.

A. Operation from Above.—

Bogojawlensky's Operation.—("Zent. für Chir.," No. 7, 1912).

Stage 1.—From a point 2½ cm. (1 in.) external to the middle line of the forehead and the same distance above the upper margin of the orbit make a cut upwards for about 9 cm. (3½ in.), then continue the cut backwards for 9 cm. and downwards for the same distance. Along the line of the scalp incision divide the bone with forceps, saw or surgical engine. A large osteoplastic flap with pedicle below is thus outlined. Attend to hemostasis and apply dressings.

Stage 2.—After several days or weeks elevate and reflect downwards the outlined flap of bone and scalp. Raise the head end of the table to 30°. Let the patient's head hang backwards over the end of the table. The raising of

the head end of the table prevents loss of cerebrospinal fluid. Make an H-shaped incision through the dura and reflect the dural flaps thus formed. With finger and brain spatula slowly and carefully lift the frontal lobe from the roof of the orbit. The dependent position of the head permits the weight of the brain to aid in this maneuvre so that it is not necessary to apply retractors to the brain. The optic commissure and any tumor of the hypophysis become visible and accessible.

McArthur's Method (Trans. Surg. Section A. M. A., 1912).

1. Place the patient in Bogojawlensky's position. Make the incision ABCD, Fig. 39, penetrating to the bone. The incision AB is 3 to 4 cm. (1⅛ to 1½ in.) long. Reflect the flap (including the periosteum) upwards. With the elevator introduced through the wound CD separate the periosteum from the orbital roof and displace the orbital contents downwards using a teaspoon as a depressor. The periosteum being kept intact the orbital contents are not seen.

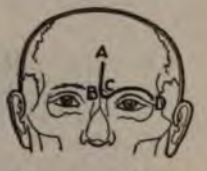


FIG. 39.—McArthur's incision for hypophysectomy.

2. With a ¼ inch trephine penetrate the frontal prominence 4 cm. (1½ in.) above the middle of the supra-orbital arch. Preserve the button of bone in warm salt solution. Beginning at the trephine opening, with DeVilbiss forceps make a curvilinear cut through the bone, concavity downwards, the inner end terminating at the frontal sinus, the outer at the outer aspect of the external angular process, thus invading somewhat the temporal fossa. With an osteotome divide the outer wall of the frontal sinus. Divide the external angular process. Elevate and remove the loosened frontal fragment; preserve it in warm salt solution. With rongeurs cut away the orbital roof back close to the optic foramen, being careful not to injure the dura.

"With this completed one can slowly and carefully detach from the bone the dura covering the inferior surface of the frontal lobe, at the same time having the latter raised by a long thin angular retractor in the hand of a skilled assistant, in whose other hand a spoon retractor displaces the orbital contents downwards. When one has reached the anterior clinoid process and the free edge of the wing of the sphenoid, which can be recognized with probe, blunt hook or finger, orientation becomes easy."

3. Note the dura between the clinoid processes and make a 2 to 3 cm. (¾ to 1⅜ in.) transverse incision through it with a fine hook-shaped knife about 0.5 cm. (⅜ in.) above the level of the floor of the anterior fossa, thus avoiding "the small, transverse venous sinus that occupies the groove between the optic foramina (this groove it was long taught, harbored the optic chiasm)." Through the dural opening the optic nerve, chiasm and the pituitary tumor come into view.

4. Treat the disease by evacuating fluid or removing tumor tissue with a fine curette.

5. Permit the frontal lobe to fall back into place. Replace the bone removed. Replace the flap of soft parts, suturing the periosteum separately. Close the skin wound. Introduce a rubber tissue drain to the dura.

McArthur has found that but little scar or deformity results. His method

is perhaps the safest and easiest means of performing an extremely difficult operation.

Frazier's method ("Annals Surg.," Feb., 1913) is almost the same as McArthur's. Reflect an osteoplastic flap from the right frontal region, the pedicle being lateral; remove the supra-orbital ridge *en bloc* with a portion of the orbital roof; remove with rongeurs the remainder of the roof of the orbit down to the optic foramen; elevate the frontal lobe; depress the orbital contents; incise the dura sufficiently to lay bare the cavity of the sella turcica (Fig. 40).

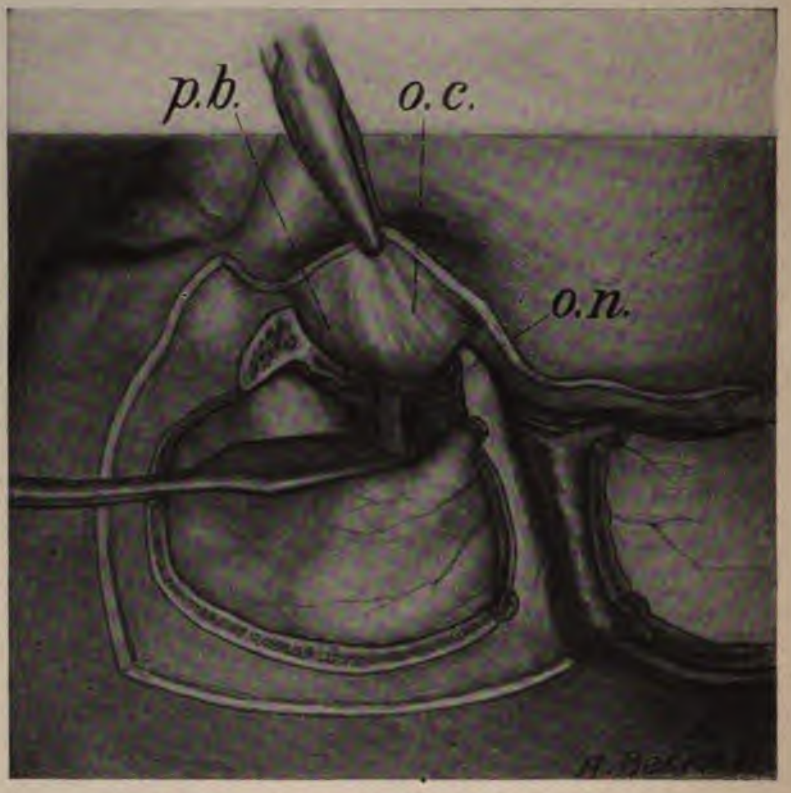


FIG. 40.—Hypophysectomy. (*Frazier, Annals of Surgery.*)

B. Operation from in Front and Below.—

Kanavel (" Journ. A. M. A.," November 20, 1909) devised an intranasal route by which to expose the hypophysis and yet avoid all disfiguring scars. This operation he worked out on the cadaver, but it was first used on the living by A. E. Halstead ("Surg., Gyn., Obstetrics," May, 1910) who associated Kanavel with himself in the operation. Montgomery West (" Journ. A. M. A.," April 2, 1910) has devised a method similar to Kanavel's but does the work entirely through the nostril without dislocating the nose. Both Kanavel and West suggest that it may be well to operate in two stages; in the first stage clearing the way to the sella turcica (this may be done under local anesthesia), in the second stage removing the tumor.

The following description is made up from the writings of Kanavel, Halstead and West and refers to operation completed in one stage.

Anesthesia.—After anesthesia is induced in the usual manner Kanavel continues the administration of ether by the rectal method, while Halstead performs tracheotomy and gives chloroform through a Trendelenburg cannula. To the author it seems that laryngotomy and the use of chloroform through Butlin's cannula is simpler and safer than tracheotomy. The advantage of anesthetizing through a tracheotomy or laryngotomy cannula over the rectal method consists in the ability to plug the pharynx thoroughly and the avoidance of all respiratory troubles. Before giving the anesthetic, plug the nasal passages carefully from the anterior nares to the sphenoidal cells with strips of gauze soaked in adrenalin solution.

The Operation. *Step* 1.—Tampon the pharynx. Remove the adrenalin pack. Raise the upper lip. Make a horizontal incision through the mucosa of the lip about 5/8 inch from the muco-cutaneous junction and parallel to the alveolus. Through this wound dissect upwards freeing the nose from its lateral attachments.

FIG. 41.—Hypophysectomy. (*Kanavel, Jour. A. M. A.*)

Step 2.—With strong scissors or bone forceps divide the septum along its inferior attachments (line b, Fig. 41). Divide the attachment of the septum to the vertical plate of the ethmoid (line a, Fig. 41). Turn the nose and with it the separated part of the septum upwards on to the forehead.

Step 3.—Remove the lower and middle turbinates, the vomer and the perpendicular plate of the ethmoid. The anterior wall of the sphenoidal sinus is now exposed.

Step 4.—Penetrate the anterior wall of the sphenoidal sinus. Sometimes the tumor will now appear having eroded the sella turcica. If this has not occurred, open the sella turcica by means of a long narrow chisel. While opening the sella turcica it is of prime importance to adhere strictly to the middle line for fear of damaging the carotid arteries and the optic nerves.

Step 5.—Treat the disease by evacuating any cyst which may be present or gently curetting away tumor tissues.

Step 6.—Pack the cavity with iodoform gauze. Replace the nose. Suture the septum. Suture the wound in the mouth.

Results.—The results of Kanavel's operations have been most excellent as regards absence of deformity. There has been no recognizable deformity in any of the patients submitted to operation.

The following surgeons have operated by the Kanavel method or some modification of it:

Halstead, A. E. ("Surg., Gyn., Obst.," May 10), two, one death. Kanavel, two, one death. Mixter, S. J., one, no death.

In Mixter's case and in Halstead's successful case the results were most gratifying. Kanavel (personal communication) writes: "My first case lived about five weeks and then died from a recurrence. After the operation he

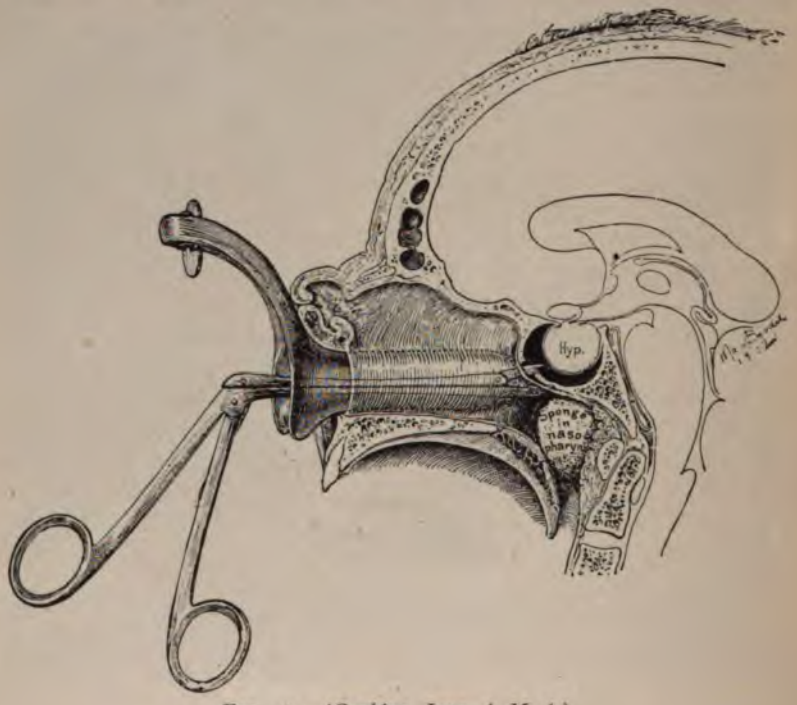


FIG. 42.—(*Cushing, Jour. A. M. A.*)

had been up and left the hospital. My second case was one of the adipose genital type, and has remained perfectly well ever since the operation, which relieved him of all the symptoms of which he complained, and with the use of the anterior lobe of the pituitary gland he is now beginning to grow."

Fig. 42 (Journ. A. M. A., Oct. 31, 1914) gives some idea of how Cushing attacks the pituitary body. That surgeon in 1914 had performed 16 transphenoidal decompressions with 3 deaths and 58 transphenoidal extirpations (on 52 patients) with 4 deaths. He writes:

"The results of the transphenoidal operation, which, as has been made clear, is carried out chiefly for the relief of chiasmal involvement, have been most gratifying in the 61 survivors in the 68 cases. Progressively failing vision

has become stationary or has been slightly regained over periods varying from a few months to several years in 22 cases. There has been a prompt widening of the field with marked improvement of vision, often with return to the normal, in another 22 cases. In two patients vision was temporarily made worse as a result of the operation, but there was subsequent great improvement. Though vision had been completely lost in 5 cases before the operation, in 2 of the cases it was partially regained. In 8 cases it was unaffected before the operation, and still remains so. In only 3 cases was there a progressive failure of vision despite a successful operation and in all of them the tissues removed showed a malignant transformation of the lesion to which the patients have since succumbed."

CHAPTER III

FRONTAL SINUS

Operation on the frontal sinus is indicated in empyema of that cavity. Frontal empyema is usually a concomitant of some form of chronic rhinitis. Either as a preliminary or complementary step in the operation it is wise to remove the anterior portion of the middle turbinated bone in order to simplify drainage.

The Operation.—Shave the eyebrow. Clean the field of operation. Protect the eyes with aseptic pads.

Step 1.—From the root of the nose make a curved incision outwards, parallel to and ⅛ inch above the upper margin of the orbit. The incision extends to a point just external to the supraorbital notch and penetrates to the bone. With the periosteal elevator separate the soft parts from the bone until the outer wall of the sinus is exposed

Step 2.—With a bur, small trephine, or gouge carefully remove the exposed wall of the sinus, immediately to the outer side of the middle line, above the root of the nose. Only a very small area of bone should be removed at this time, and care is necessary lest such an instrument as the chisel should suddenly penetrate the thin bone and injure the posterior or inferior walls of the cavity. As soon as the bone is penetrated, the mucosa lining the sinus pouts into the wound. Incise the mucosa. Gently explore the cavity with a probe and with gouge or forceps (guided by the probe) remove the anterior wall of the sinus. Some surgeons are careful *not* to remove any of the orbital margin lest an ugly deformity result; others carefully remove every particle of bone which might interfere with the soft parts being brought in absolute contact with the deep wall of the sinus, the aim being to obliterate the cavity. Obliteration of the cavity is often necessary, but as it causes marked deformity one is wise to try less mutilating procedures first.

Step 3.—With a sharp spoon remove all granulation tissue from the sinus and from its opening into the nose. With a small sharp spoon cleanse every nook and cranny. Be careful not to injure the orbital plate. Pass the sharp spoon from the postero-internal angle of the sinus downwards into the nose.

The instrument goes through some of the ethmoidal cells and creates a good passage for drainage.

Step 4.—Pass a rubber tube from the sinus into the nose. Some surgeons do not permit the upper end of the tube to emerge through the skin, but close the cutaneous wound entirely, trusting to nasal drainage alone, as in Barth's operation; most operators place the tube so that it emerges both through the skin and the nose. Through-and-through drainage is probably best to begin with. During the after-treatment, if it becomes necessary to withdraw the tube tem porarily, it is well to fasten a thread to the tube, so that as the tube is withdrawn the thread may take its place and serve as a guide for the introduction of a clean drain. Close all excess of wound with sutures. Dress.

After-treatment.—Warn the patient not to blow his nose violently, otherwise emphysema will result. When nasal drainage alone is provided, leave the tube *in situ* as long as possible, because once removed it is very difficult to replace. When through-and-through drainage is provided, withdraw the drain gradually, through the nose, as suppuration lessens. When drainage fails to cure the disease, the sinus must be obliterated by the method indicated in Step 2.

Killian's operation is very radical and successful. (Freudenthal, "Jour. Am. Med. Assoc.," Feb. 11, 1905.)

Step 1.—Make an incision down to the bone the whole length of the eyebrow, just above the orbital margin. Continue the incision at its inner end down the middle of the nasal process of the superior maxilla.

FIG. 43.—Barth's operation.

Step. 2.—Open and explore the sinus either above or below the orbital margin.

Step 3.—With chisel and mallet make a furrow through the bone immediately above and parallel to the margin of the orbit. Remove with forceps the whole anterior wall of the frontal sinus above the furrow.

Step 4.—Clean out the sinus and remove its mucous membrane.

Step 5.—Remove with forceps the whole (orbital) floor of the sinus, leaving the orbital margin intact for cosmetic reasons.

Step 6.—Resect the frontal process of the superior maxilla and the rest of the floor of the sinus.

Step 7.—Resect the anterior and middle ethmoidal cells and the respective parts of the middle turbinal. These structures are always affected.

Step 8.—Close the wound after providing for drainage by a rubber tube.

The extensive removal of the floor of the sinus and consequent opening of the orbit cannot be without danger. The inevitable entrance of pyogenic organisms into the non-resistant fatty tissues must often give rise to orbital abscess.

Barth's Operation.—A little to the side of the middle at the root of the nose make a longitudinal incision 1 inch in length, down to the bone. With a chisel carry the above incision through the nasal process of the frontal bone and the nasal bone. At the upper and lower angles of the wound, by means of a narrow chisel, make horizontal cuts outwards through the bone. The flap of

bone thus formed is pried outwards (Fig. 43) like a trap-door with hinge placed externally. The upper part of the opening is filled with the mucous membrane of the frontal sinus. Cut through this bulging mucous membrane. Through the above opening diseased tissue may be inspected and removed, free drainage through the nose may be provided, and if necessary the opposite sinus may be opened and treated. When the operation is completed, the bone flap is restored to place and the vertical skin-incision is sutured.

CHAPTER IV

TIC DOULOUREUX

In severe cases of trigeminal neuralgia, after treatment by medicine and by removal of sources of peripheral irritation and particularly of infection has failed, operation offers the only hope of amelioration or cure. Very many operations have been devised, but not all of them are useful. The earliest operations consisted in the subcutaneous or open division of the nerve trunks as they left or entered their bony canals. The supraorbital nerve was divided as it emerged from the notch of the same name, the infraorbital at the infraorbital foramen, and the inferior maxillary as it entered the posterior dental canal. In certain cases such operations gave marked and occasionally permanent relief, but after simple division of a sensory nerve repair can take place with great rapidity, so that the neuralgia usually recurs at an early date.

Thiersch, after exposing the nerves at their exit from their bony canals, seized them in strong forceps and by slow twisting and pulling, forcibly extracted a varying amount of them from their canal. Recurrence after this procedure was neither so prompt nor so constant as after simple division. Undoubtedly the best method of operating upon the nerve-trunks is by the removal of as much of them as is possible, or by injecting into them materials which will either destroy or diminish their power of conduction.

INJECTIONS INTO THE NERVES

Schlösser was the first to make injections into the trunks of the nerves at the base of the skull in treating trifacial neuralgia. Ostwalt followed him and injected the three branches of the nerve through the mouth. Lévy and Baudouin devised and systematized a simple and safe method for making the injections without incurring the dangers incident to invading the mouth. Patrick has followed their method with much success. The author has followed Murphy's modification of the Lévy-Baudouin procedure and finds it easy and fairly satisfactory.

Ostwalt's Injections ("La Presse Méd.," Dec. 16, 1905).—Ostwalt injects 1 to 1½ c.c. of 80 per cent. alcohol (to which is added .01 cocaine or stovaine) into the trunk of each of the branches involved where it emerges from the skull. "As usually several branches (most commonly the second and third) are affected at the same time, I make an injection in two or three stages;

first at the foramen ovale then at the foramen rotundum and last, if necessary, in the sphenoidal fissure. To reach the foramen ovale, I introduce my bayonette-shaped needle (Fig. 44), mounted on the syringe, behind the wisdom tooth and make it penetrate the mucosa, submucosa and external pterygoid muscle, then I pass up into the pterygoid fossa along the external wing of the pterygoid process until it strikes the great wing of the sphenoid. I then direct the point of the needle backwards into the angle formed by the pterygoid process and the great wing of the sphenoid until bony resistance disappears, and the foramen ovale is reached. As soon as the fluid is injected here I conduct the needle, always in the above-mentioned angle of the pterygoid fossa, forwards until once more the sense of bony resistance is lost. The needle is now at the border of the sphenomaxillary fossa. Keeping the needle continuously on the anterior surface of the pterygoid fossa I push the needle upwards 6 to 9 mm., reaching the foramen rotundum, and can feel the upper border of the foramen formed by the

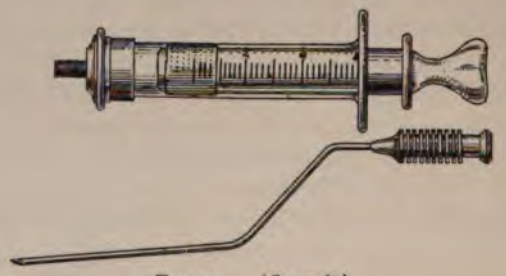


FIG. 44.—(*Ostwalt.*)

little osseous bridge with separates it from the sphenoidal fissure. In the rare cases where the first branch is involved along with the second or with the second and third branches, it is only necessary (once the injection of the superior maxillary is completed) to pass the needle about 2 mm. higher, passing above the little osseous bridge already mentioned, where it encounters the ophthalmic branch in its passing through the sphenoidal fissure." Ostwalt has made 250 deep injections in tic without any ill effect. In at least one-third of the cases there was recurrence at the end of four or five months, but these recurrences were less serious than the original tic and were relieved by one or two more injections. Although as a rule one injection gives improvement in tic, yet two, three or four seances are generally required.

Lévy and Baudouin write ("La Presse Méd.," Feb. 17, 1906): "We have used, experimentally and clinically, alcohol and chloroform in which we have dissolved sublimate or carbolic in the proportion of 1 per cent." [One per cent. of sublimate is evidently a mistake—Author.] "We do not employ osmic acid for fear of necrosis. The following is our practice. We inject 1 or 2 c.c. of alcohol (with or without cocaine) of increasing strength—70, 80, 90 per cent.; then we repeat the injections of these strengths of alcohol after adding 4 drops of chloroform to each c.c. of alcohol. Experiments on animals show that these substances in the doses employed by us are harmless even when injected intravenously. The puncture itself is but slightly painful. Generally when the nerve trunk is reached the patient complains of a pain

through the corresponding territory. . . . The injection should be made very slowly and the needle ought not to be withdrawn for fifteen or twenty seconds. . . . After from two to five minutes the patient complains of a feeling of stiffness, of swelling, then of numbness in the territory of the injected nerve. Sometimes one can demonstrate a complete anesthesia which may persist for a long time. Usually the injection is followed by an exacerbation of the pain for some hours and the patient ought to be warned of this. In the region of the injection there is a slight temporary edema and after injection of the inferior maxillary nerve there is a certain difficulty in opening the mouth. As a rule six or eight injections are required at intervals of three or four days. The tolerance of the patient must regulate the time and strength of the injection. Experience has taught us that it is necessary to inject at least two of the branches of the trifacial nerve. In case of neuralgia of the inferior maxillary or of the ophthalmic nerves, the superior maxillary ought also to be injected. In case of neuralgia of the superior maxillary we inject the inferior maxillary also." J. B. Murphy uses from seven to fifteen minims of a 2 per cent. solution of osmic acid as an injection material. The author has had the pleasure of seeing some of the excellent results secured by Murphy.

The Operation.—The only special instrument required is the Lévy-Baudouin cannula. The cannula is of steel 10 cm. long, 1½ mm. in diameter (Fig. 45), and is graduated in centimeters. The mandrin with which the cannula is

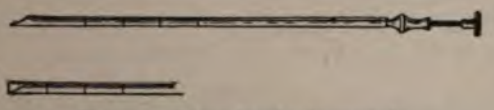


FIG. 45.—Lévy-Baudouin cannula.

provided, when pushed home protects the short point of the cannula so that no injury can be inflicted on such structures as arteries.

A. Injection of the Inferior Maxillary Nerve.

1. *Lévy-Baudouin Method.*—Note the bony prominence at the junction of the zygoma with the anterior bony wall of the external auditory meatus. Choose a point on the lower edge of the zygoma 2.5 cm. anterior to the above bony prominence. At this point introduce the cannula directly inwards and immediately under (in contact with) the zygoma for a depth of 4 cm. when its point must be at the foramen ovale. To avoid injuring the middle meningeal artery, push the mandrin home in the cannula (thus rendering the instrument blunt) as soon as a depth of 1.5 cm. is reached, retire the mandrin when the depth of 4 cm. is attained, and inject the chosen solution.

2. *Murphy's Method.*—Choose a point at the middle of the *upper* edge (Figs. 46 and 47) of the zygoma and here introduce the needle passing it directly inwards until it strikes either the squamous portion of the temporal bone or the great wing of the sphenoid and guided by these passes inevitably over the foramen ovale at a depth of 1½ inches (4 cm.) from the outer surface of the zygoma.

3. *Gascard's Method.*—(La Pr. Med., August 25, 1919.) Palpate the angle formed by the zygoma and the ascending portion of the malar bone. Introduce

the needle vertically in this angle immediately above the zygoma. At a depth of about 2½ cm. the needle will hit the vertical portion of the great wing of the sphenoid. Lower the point of the needle a few millimeters to pass round

FIG. 46.—Injections for tic.

the angle formed by the vertical and horizontal parts of the great wing of the sphenoid and push the needle onwards with its point scraping against the inferior surface of the bone until it reaches the foramen ovale exactly 5 cm. from

FIG. 47.—Injections for tic.

the superior zygomato-malar angle. The needle cannot penetrate to the depth of 5 cm. unless it is in the right direction.

B. Injection of the Superior Maxillary Nerve.

1. *Lévy-Baudouin Method.*—Prolong the line of the posterior border of the ascending (orbital) process of the malar bone to the lower edge of the zygoma and insert the needle ½ cm. posterior to this point. Direct the needle inwards

and slightly upwards in a direction which would attain at the depth of the foramen rotundum (5 cm.), the level of the inferior extremity of the nasal bone. When the needle has penetrated 5 cm. its point has reached the nerve where it emerges from the foramen rotundum into the pterygo-maxillary fossa.

2. *Murphy's Method.*—Draw an imaginary line vertically downwards from the external angular process of the frontal bone; where this line crosses the inferior margin of the zygoma introduce the needle directly under the zygoma. Pass the needle inwards and a trifle upwards until it impinges against the back of the superior maxilla. Guided by the maxillary bone push the needle on until its point has penetrated 1¾ inches (4½ cm.) or slightly more from the surface of the malar and has reached the foramen rotundum.

C. Injection of the Ophthalmic Nerve.

Lévy-Baudouin Method.—These authors write: "The first branch of the fifth pair dividing inside the cranium one cannot attack its trunk. Of the three branches the nasal is hardly accessible in the midst of the important motor nerves which surround it. To reach the frontal and lachrymal nerves the orbital route is indicated. As a path to the nerve we have chosen the external wall of the orbit at the level of the inferior extremity of the external angular process of the frontal bone. Inserted here the needle passes below the lachrymal gland and follows the periosteum without injury to the eye or to any important organ. At a depth of 35 or 40 mm. one makes the injection after withdrawing the mandrin. The patient ought to have his eyes closed. The needle has some difficulty in penetrating the outer portion of Tenon's capsule which is very thick."

Hugh Patrick has had much experience in the use of deep injections of alcohol for the relief of tic and makes some characteristically cautious and sensible remarks thereon ("Journ. A. M. A.," Sept. 19, 1907), a synopsis of which is given here:

The number of injections necessary for relief depends on the accuracy with which the alcohol is placed. A single injection within the nerve sheath will stop the pain at once. A number of trials may be necessary before this can be accomplished. An injection *near* though not *in* the nerve is not without value because the alcohol "undoubtedly diffuses sufficiently to reach it. In such cases the relief comes after some minutes or hours and does not last long. Consequently I believe it is wise to continue the injections even though the patient is having no pain, until the characteristic sensory phenoma" (pain and feeling of swelling and stiffness in the area supplied by the nerve; analgesia in area) "announce marked action on the nerve." If pain returns there seems to be no objection to secondary injections. In conversation with the author Patrick gave the impression, no doubt correct, that a permanent cure could hardly be expected from injections; but the operation is trivial, usually gives at least temporary relief and may be apparently repeated indefinitely.

Fischer ("Münchener med. Woch.," 1907, No. 32) reporting the result of injections of alcohol in Erb's clinic for various neuralgias warns against their use in mixed or in motor nerves as dangerous consequences have arisen; yet Patrick and others have injected alcohol into the facial nerve with good results in facial spasm (not tic) without causing troublesome facial paralysis.

D. Injections into the Gasserian ganglion itself have been made not only to relieve the pain of tic but to produce anesthesia under which extensive operations have been performed.

Harris' Method.—Step 1.—Draw an imaginary line from the "incisura notch" (the deep notch in the external ear above the lobule and between the tragus and antitragus) to the lower border of the *ala nasi*. This line in the average skull corresponds to the lower border of the sigmoid notch. Mark out the lower border of the zygoma, especially the tubercle in front of the glenoid fossa; the anterior margin of this tubercle is precisely 1 inch in front of the external auditory meatus. Draw a vertical line through the anterior margin of the tubercle. This line meets the *incisura-ala nasi* line practically at right angles. "A plane through this vertical perpendicular to the zygoma and side of the cheek passes through the foramen ovale."

Step 2.—Choose a point on the *incisura-ala nasi* line ⅛ to ¼ inch in front of the crossing-point of the two lines and there introduce the needle upwards, backwards and inwards. Harris writes: "My needle must be directed very slightly backwards in order to hit the plane through the tubercle line at the depth of the foramen ovale, which I have found to vary from 42 to 54 mm., according to the thinness or fatness of the cheek, and according to the narrowness or great width of the head of the individual. The angle of backward direction varies from 15° in thin-faced narrow-headed subjects to even vertically inwards in stout wide-headed people. Similarly the angle of upward direction varies rarely as much as 15° and it may be almost horizontal."

When the inferior maxillary nerve is reached the patient may complain of pain in the lower teeth and lip. Attach a syringe to the needle and inject about 1½ c.c. of 1 per cent. eucaine solution. If the nerve itself has been injected there will be immediate anesthesia of the lower lip and chin and the rest of the operation will be practically painless.

Step 3.—Keeping the needle in the original direction, feel with its point for the foramen ovale. When the foramen is found push the needle onwards into the substance of the ganglion for about ¼ inch. Attach a syringe to the needle and slowly inject a drop or two of alcohol. If the needle is in the ganglion considerable resistance to the push of the piston will be noticed, when another 1 to 1½ c.c. may be injected a few drops at a time. During the injection test sensation on the forehead by pricking with a blunt pin; when a pin prick or pin pressure is no longer noticeable, stop the injection and slowly withdraw the needle. If when the injection is begun no resistance is felt to the push of the piston and if the patient instantly complains of severe pain at the base of the skull and back of the head, the needle is not in the nerve but in Meckel's cave and cerebrospinal fluid may escape through the needle. Under these circumstances withdraw the needle slightly and reintroduce it through the posterior portion of the foramen so as to keep its point within the substance of the ganglion. If the patient complains of sudden pain in the cheek and nose after the needle enters the foramen, it means that it has passed in front of the ganglion and has struck the root of the superior maxillary nerve before the nerve has reached the foramen rotundum. Harris uses nickelled-steel needles 3 inches and 3½ inches in length and 1.25 mm. and 1.4 mm. diameter, provided

with a stylet, and with a short sharp point bevelled at an angle of 20 per cent. The Lévy-Baudouin cannula—10 cm. long, 1½ mm. diameter, graduated in centimeters and provided with a mandrin—ought to do well.

Härtel's Method. ("Zent. für Chir.," May 25, 1912.)—A stylet passed from the "impressio trigemini" through the foramen ovale will reach the masseteric region midway between the anterior margin of the ascending ramus of the lower jaw and the posterior margin of the maxillary tubercle; in 90 per cent. of skulls the stylet hits the upper alveolus in the molar region. The distance from the foramen ovale (extra-cranial) to the cheek is 5 to 6 cm.; from the outer surface of the skull at the foramen ovale to the impressio trigemini it is not less than 1.5 cm., averaging 1.9 cm. A needle passed up this line is so limited in its lateral movements that it cannot injure the cavernous sinus internally, the brain above or the carotid below the Gasserian ganglion.

Technic.—Use a very fine graduated canula 9 cm. long. Choose a point on the cheek 2 to 3 cm. behind the angle of the mouth. Anesthetize the skin here and introduce the needle upwards to pass between the ascending ramus and the maxillary tubercle until the infratemporal plane is reached. When the needle hits the hard, smooth temporal bone, feel or explore backward with the point of the needle for the foramen ovale. Härtel uses the following important landmarks to direct the needle: Viewed directly from in front aim the needle at the pupil of the eye on the same side; viewed from the side aim it at the articular tubercle of the zygoma.

As soon as the third branch of the nerve is touched there is paresthesia or shooting pains in the lower teeth and the needle may be slowly pushed through the foramen ovale until the pain in the upper jaw is evident. Now inject as slowly as possible ½ to 1½ c.c. of 2 per cent. novocain-adrenalin solution. Anesthesia is immediate and lasts 1 to 2 hours.

NEURECTOMY OF THE FIRST DIVISION OF THE FIFTH NERVE

The first or ophthalmic division of the fifth nerve enters the orbit through the sphenoidal fissure and divides into three branches—the frontal, lachrymal, and nasal. The frontal nerve, the only branch of surgical importance, divides into the supraorbital and supratrochlear. The supraorbital leaves the orbit through a notch or foramen situated at the junction of the inner and middle thirds of the supraorbital margin. With it run the supraorbital artery and vein.

NEURECTOMY OF THE SUPRAORBITAL NERVE

Locate the supraorbital notch or foramen. Make a horizontal incision through the skin, parallel to and a little below the eyebrow. Separate the fibres of the orbicularis muscle. Expose the nerve as it passes through the supraorbital notch. Divide the orbitotarsal ligament. With a flat retractor depress the orbital fat. Follow the nerve backwards from the supraorbital notch, separate it from its surroundings, divide it as far back as possible, and remove all of it in front of the point of section. Close the wound with sutures. Dress.

A good modification of the operation is the following: Expose the nerve at its exit; isolate it for a short distance; seize its undivided trunk with a narrow-bladed hemostat; rotate the hemostat so that the nerve becomes wound around the jaws of the forceps; reverse the direction of rotation. By repeating the manœuvres of rotation and working slowly and patiently almost the whole peripheral portion of the nerve and much of its central trunk can be extracted. (Thiersch.)

NEURECTOMY OF THE SUPRATROCHLEAR

The supratrochlear nerve is generally divided in the preceding operation, but occasionally it is missed and demands special attention. Draw an imaginary line from the angle of the mouth through the inner canthus of the eye. At a point a little below where a continuation of the above line crosses the eyebrow make an incision through the skin parallel to the fibres of the orbicularis muscle. Find the trochlea, which acts as a pulley for the superior oblique muscle. Locate the posterior portion of the superior oblique muscle. The supratrochlear nerve and its branch, the infratrochlear, lie upon the superior oblique muscle and may be separated from it by a strabimus hook and excised.

NEURECTOMY OF THE SECOND DIVISION OF THE FIFTH NERVE

Anatomy.—The superior maxillary nerve "commences at the middle of the Gasserian ganglion, and, passing horizontally forwards, soon leaves the skull by the foramen rotundum of the sphenoid bone. The nerve then crosses the sphenomaxillary fossa, and, taking the name of *infraorbital*, enters the infraorbital canal of the upper maxilla, by which it is conducted to the face" (Fig. 48).

"In the sphenomaxillary fossa an orbital or temporo-malar branch ascends from the superior maxillary nerve to the orbit, and two sphenopalatine branches descend to join Meckel's ganglion; while the nerve is in contact with the upper maxilla it furnishes the superior dental or alveolar branches; and on the face are the terminal branches" (Quain).

When the neuralgia is limited to the facial distribution of the nerve, the following operations may be performed:

(A) Locate the infraorbital foramen at the junction of the inner and middle thirds of the inferior rim of the orbit and about half an inch below it. It is on a line drawn from the supraorbital notch to a point between the two bicuspids. Make a curved transverse incision parallel and close to the lower margin of the orbit. Divide the orbicularis muscle in a direction parallel to its fibres. Expose the nerve as it leaves the infraorbital foramen (Fig. 49). Seize the nerve in forceps, and by traction and torsion extract as much of its trunk from its bony canal as is possible. In the same fashion extract as much of its terminal twigs as possible from the soft structures in which they run. It is extraordinary how much of the nerve can be removed in this manner if patience is exerted. This operation does not destroy the alveolar branches of the nerve. In an endeavor

to prevent recurrence one may plug the bony canal with a bone peg, silver screw, rubber tissue, or amalgam.

(B) Expose the nerve as in Method A. Opposite the infraorbital foramen make a vertical incision (a) through the soft parts joining the horizontal incision

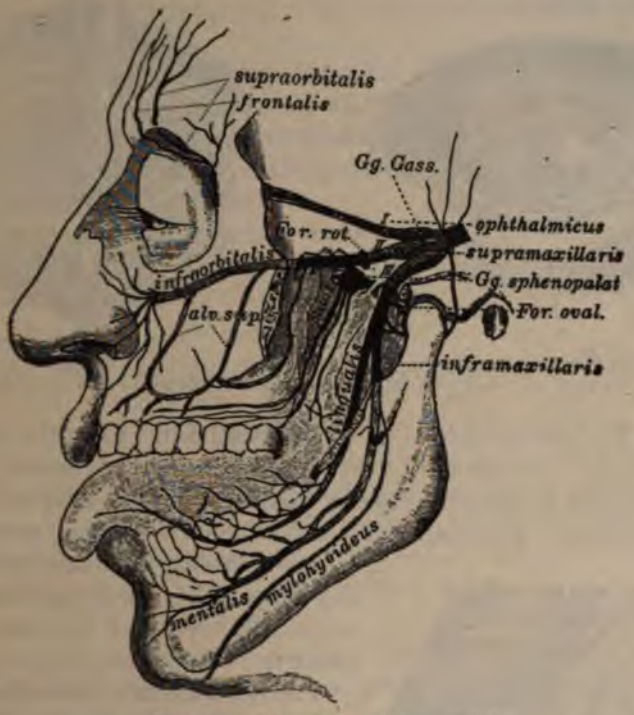


FIG. 48.—(*Esmarch and Kowalzig.*)

at right angles (Fig. 50). Divide the periosteum along the lower margin of the orbit. Separate the periosteum covering the floor of the orbit from the bone.

FIG. 49.—Evulsion infraorbital nerve.

If this is done, no orbital fat should be seen. With a flat retractor lift the orbital contents upwards (Fig. 51). With a narrow chisel cut through the bone all

round the infraorbital foramen and remove it until that part of the osseous canal which is covered by a thin shell of the bone forming the orbital floor, is exposed. With the chisel cut away the bony roof of the infraorbital canal to its posterior extremity. This can generally be accomplished without opening the antrum of

FIG. 50.

FIG. 51.

FIGS. 50 AND 51.—Excision infraorbital nerve. (*Esmarch and Kowalzig.*)

Highmore. Lift the nerve from its bed and excise it. Close the wound with sutures. Dress. The scar left by the operation is trifling. Several operations have been devised to excise the superior maxillary nerve and Meckel's ganglion by the antral route. Any operation in which the antrum of Highmore is opened is undesirable on the score of uncleanliness, and the advantages of such methods are more fully obtained by the operation about to be described.

FIG. 52.—Excision superior maxillary nerve. (*Farabeuf.*)

Pterygo-maxillary Operation. (Braun and Lossen's Modification of Lucke's Operation.)—*Step* 1.—Expose the infraorbital nerve at its exit from the bone.

Step 2.—Beginning at a point just behind and below the external angular process of the frontal bone, make an incision *backwards* and downwards to near the tragus. From the same starting-point make another incision downwards and *forwards* to the lower margin of the zygoma. Reflect downwards the triangular flap of skin and subcutaneous tissue thus outlined. With a finger saw, chisel, or Gigli wire saw divide the zygoma in front and behind. Rose recommends that before the zygoma is divided holes be bored on each side of the line of section so that everything may be ready for wiring the fragments in position on the completion of the active part of the operation. Separate the temporal fascia from the upper edge of the zygoma and turn the bone downwards. Retract the tendon of the temporal muscle backwards. The pterygo-maxillary fossa is exposed, with its fat and plexus

of veins. If one now pushes the fat back with a blunt retractor, one at the same time keeps the venous plexus and internal maxillary artery out of the way. Demonstrate the posterior orbital fissure with a probe or strabismus hook and distinguish the superior maxillary nerve and its accompanying vessel (Fig. 52). The course of the nerve from its exit from the skull is downwards, forwards and outwards. The artery runs inwards, forwards and upwards.

Step 3.—Tie a ligature round the nerve for the purpose of traction. Divide the central end of the nerve as close to the foramen rotundum as possible. By traction and torsion pull the peripheral end of the nerve out of its bony canal. By this operation the whole trunk of the nerve is excised from the foramen, rotundum to the cheek.

Step 4.—Attend to hemostasis. Replace the zygoma and fix it in position by wire or chromicized catgut sutures. Provide drainage. Close the skin wound. Dress.

NEURECTOMY OF THE THIRD DIVISION OF THE FIFTH

The inferior maxillary or third division of the fifth nerve leaves the skull through the foramen ovale and divides into an anterior, motor and a postel rior division. The latter, almost entirely sensory, divides into the auriculo-temporal, the lingual, and the inferior dental. The lingual and the inferior dental are of surgical importance, and as they are generally both involved, if either of them is affected by neuralgia, their excision may be considered as part of one operation. (See Fig. 48.)

The Operation.—Shave the temple. Clean the side of the face and the external auditory meatus, and plug the latter passage with a little gauze or better with non-absorbent cotton.

Step 1.—Beginning about the middle of the zygoma cut backwards and slightly downwards to a point a little below the tragus, then continue the incision downwards along the posterior margin of the ascending ramus to the angle of the lower jaw. From this point cut forwards along the inferior edge of the horizontal ramus for about ¾ inch. The cut only involves the skin and subcutaneous tissue. Reflect the skin-flap, outlined as above, forwards. The flap, consisting of skin alone, leaves the branches of the facial nerve uninjured. Note carefully the position of Stenson's duct and of the anterior lobules of the parotid gland. Make a transverse incision parallel to and below Stenson's duct, directly down to the bone, at a point about ½ inch below the sigmoid notch. Any portions of the parotid gland which may be in the way must be retracted backwards uninjured. With a periosteal elevator denude the outer surface of the ascending ramus of the jaw for a distance of one inch or more below the sigmoid notch.

Step 2.—Apply a ¾-inch trephine to the outer surface of the bone, the upper edge of the trephine being not more than ¼ inch below the edge of the sigmoid notch (D, Fig. 53). With the trephine perforate the ascending ramus and remove the button of bone. With rongeur forceps remove the bridge of bone

(C, Fig. 53), separating the trephine hole from the sigmoid notch. The result of the above manœuvres is to deepen the sigmoid notch while the coronoid and articular processes are left in uninterrupted connection with the rest of the jaw.

Step 3.—Retract the tendon of the temporal muscle forwards. With two pairs of dissecting forceps pick away any fat which may be in the way and demonstrate the external pterygoid muscle, which passes transversely across the wound from the outer surface of the external pterygoid plate to the articular process of the lower jaw. Note also the fibres of the internal pterygoid running downwards and backwards from the pterygoid fossa to the inner surface of the lower jaw near its angle. Retract upwards the lower fibres of the external pterygoid and thus expose both the lingual and inferior dental nerves, which, resting upon the internal pterygoid muscle, come out from under the external pterygoid and run downwards. The lingual nerve lies a little internal and anterior to the dental. Tie a ligature, for purposes of traction, round each nerve. Trace the nerves up to the foramen ovale and divide them there. Trace the nerves downwards and either divide them or by torsion and traction tear away as much of their peripheral portion as can be extracted. It is easy to remove more than an inch of the nerves.

FIG. 53.—Excision inferior dental nerve.

Step 4.—Attend to hemostasis. Close the skin-wound. Drainage may or may not be used. Dress.

In certain cases of very painful cancers of the tongue relief may be secured temporarily, at least, by section of the lingual nerves.

Leriche (Lyon. Med., Jan. 18, 1914) agrees with Hayem that besides aerophagy due to a reflex having its origin at the level of the stomach certain cases are due to a primary hypersalivation. In one case of the latter after various régimes had failed to relieve, he divided both lingual nerves and the right auriculo-temporal nerve. The desired result was obtained; there was no longer hypersalivation, the aerophagy and its consecutive gastric disturbances disappeared. The patient was satisfied but complained of an impediment due to the lingual anæsthesia.

The simplest method of exposing the lingual nerve is through the mouth. Open the mouth widely. Pull the tongue forcibly to the opposite side so as to make the nerve stand out in relief below the mucous membrane of the tongue behind the last lower molar tooth. Make a ½-inch incision along the course of the nerve and after picking it up with a blunt hook excise as much as desired. The wound in the mucosa requires no sutures.

The auriculo-temporal nerve may be exposed by a ½-inch vertical incision midway between the tragus and the condyle of the jaw at the level of the posterior root of the zygoma. The nerve is posterior and parallel to the superficial temporal artery.

Inferior Dental Nerve. Transmaxillary Neurectomy.

Step 1.—From the angle of the lower jaw make an incision for about 1½

inches forwards along the lower border of the horizontal ramus. With an elevator separate the masseter from the bone. If necessary continue the incision upwards along the posterior border of the ascending ramus for about ¾ inch. Expose the greater part of the external surface of the ascending ramus.

Step 2.—Note the line of the free border of the teeth of the lower jaw and continue this as an imaginary line across the ascending ramus; on this line choose a spot midway between the anterior and posterior borders of the ramus and at this spot apply a Doyen's bur (about 16 mm. in diameter) and bore a hole sufficiently deep to expose the inferior dental canal and the nerve in it. The bur is a better instrument to use than a trephine as it is not so liable to injure the nerve.

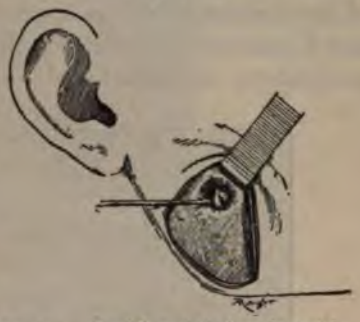


FIG. 54.—Excision inferior dental nerve. (*Lenormant.*)

Step 3.—The nerve is seen lying in the depth of the wound (Fig. 54). Pick up the nerve in a forceps and evulse it after the manner of Thiersch. Pack the bone canal with rubber tissue, hard paraffin, amalgam or some such material.

Step 4.—Close the wound.

The author has found this operation very satisfactory.

All the operations of neurectomy which have been described give at least temporary relief, but too frequently the *tic* returns after the lapse of a year or two. Occasionally the patient does not seem to get immediate relief from his pains. The author has in mind one case in which he removed portions of the inferior dental and lingual nerves. The patient suffered from neuralgia for one or two days after the operation. The pain was at once relieved on the removal of bloody fluid which had collected in the deep wound. Had the wound been efficiently drained, the temporary trouble might have been averted.

None of the operations of neurectomy for tic douloureux which have been described here are dangerous when performed by an experienced surgeon, but they are not a proper field for invasion by a tyro in surgery. In almost all the operations the wounds while large, are so situated as to cause but little deformity from scar, especially if the subdermal suture is used in closing them.

HARTLEY-KRAUSE OPERATION

It has been shown that tic douloureux almost always recurs after even the most extensive excision of the nerve-trunks involved. It has also been shown (Keen and Spiller) that in the Gasserian ganglion very marked degeneration is present. When neurectomy fails to give permanently good results, it is most logical to attack the Gasserian ganglion. This has been done in many cases with excellent effect. The Gasserian ganglion may be exposed either

from below or from above. The former method has been thoroughly studied by Rose, Andrews and others. Their route entails temporary resection of the zygoma and the coronoid process, the use of the inferior maxillary nerve as a guide to the foramen ovale, exposure of the base of the skull beside that opening, the removal of a button of bone from the exposed portion of skull with a trephine, and lastly a rather haphazard removal of the ganglion when it is reached. Anyone who has had occasion to operate in the neighborhood of the foramen ovale can appreciate the difficulties of the operation. Hartley and Krause almost simultaneously devised a method of reaching the Gasserian ganglion by an intracranial route.

FIG. 55.—(*Frazier, Jour. A. M. A.*)

Position of Patient.—Frazier places the patient in the sitting posture (special operating chair) claiming that less ether is required, that there is less venous bleeding and that as the plane of the floor of the skull is level with the surgeons eye he may stand erect and look directly at the structures on which he is working.

Pussep (Russki Wratsck, 1912, No. 2. Zent für. Chir., 1912, No. 24) advises that the patients head be placed hanging down and somewhat to the side so that the weight of the brain acts in place of a retractor. (See Bogojawlensky's position.)

Anesthetic.—Ether. Deep anesthesia is not required and after the root is divided the anesthetic may be discontinued.

The Operation.—The shortest route to the ganglion is from the middle of the zygoma.

Step 1.—Make and reflect forwards the skin flap shown in Fig. 55. This avoids injury to the upper division of the facial nerve. Make and reflect backwards and forwards the temporal musculo-aponeurotic flaps as shown in Fig. 55.

FIG. 56.—(*Frazier, Jour. A. M. A.*)

FIG. 57.—(*Frazier, Jour. A. M. A.*)

Attach all these flaps by sutures to the drapings around the operative area and thus avoid the use of retractors. Control hemorrhage as described in Cushing's subtemporal decompression.

Step 2.— A short distance above the zygoma open the skull with a suitable bur. Enlarge the opening with rongeurs until it is about 4 cm. (1½ in.) in diameter. The *lower margin* of the opening *extends to the base of the skull.*

Step 3.—Separate the dura slowly from the temporal bone and the base of the skull following the middle meningeal artery to the foramen spinosum Plug

FIG. 58.—(*Frazier, Jour. A. M. A.*)

the foramen with a twisted bit of moistened cotton or with bone wax, and divide the artery (Fig. 56,). Continue the separation to the foramen ovale.

Step 4.—Note the dural reflection on the mandibular division of the nerve as it enters the foramen ovale (Fig. 57). Open this reflection and enlarge the opening until the upper surface of the ganglion is stripped of its dural covering. Follow the ganglion upwards until at the apex of the petrous bone the sensory root is seen (Fig. 58).

FIG. 59.—Left Gasserian ganglion exposed from the side.

Step 5.—Isolate the sensory root; pick it up on a small blunt hook and by gentle traction sever it from its central attachment.

Step 6.—Close the wound.

During the operation a proper retractor provided with an electric light (Fig. 57) is valuable. To avoid keratitis Frazier advises the use of goggles for a year after operation when the patient is out of doors.

Jonathan Hutchinson, Jr., advocates division of the superior and inferior maxillary nerves and removal of the corresponding portion of the ganglion leaving intact the ophthalmic division and its portion of ganglion (Fig. 59).

THE ABBÉ OPERATION

Abbé, to avoid the dangers of hemorrhage, shock, and prolonged operation, has given up attempts to formally resect the Gasserian ganglion. He performs an intracranical neurotomy or, preferably, neurectomy, and then prevents reunion of the divided nerves by interposing a layer of thin rubber tissue, sterilized by immersion in corrosive sublimate solution, which is washed off with salt solution. To lesson hemorrhage from the middle meningeal artery Abbé ligates the external carotid just above the thyroid.

"Ligate the external carotid; make a straight incision in the temporal fossa above the zygoma; split the temporal muscle, scraping it widely from the bone, and enter the skull by a small trephine opening, rapidly enlarged by rongeurs to one and one-half inches in diameter. Expose the second and third branches from the Gasserian ganglion to the foramina. Seize each at the foramen by a narrow clamp, cut it, and resect a half-inch or tear it from the ganglion; push back the dura well beyond the foramina; arrest bleeding by a moment's pressure, and spread over the bone a piece of sterile rubber tissue, enough to more than cover both foramina, one inch wide by an inch and a half in length, which must be pressed upon the bone by a strip of gauze packed over it for a couple of minutes. When this is removed, the rubber tissue lies in close contact with the skull and the dura is allowed to settle down to its place upon it. The wound is then closed by a few fine catgut sutures and drained for a day at its lower angle." ("Trans. Am. Surg. Assoc.," 1903.)

G. R. Fowler has used Crile's plan of temporary occlusion of both common carotids and found it useful. In one case a tape passed round the carotid and secured by a clamp, pressed against the internal jugular vein and caused much venous oozing during the operation.

When should one practise excision of the Gasserian ganglion? In cases of intolerable tic douloureux one should try the milder operations of neurectomy, as they give at least temporary relief, and so permit the strength of the patients to be built up. This is important, as the sufferers from tic douloureux are often much reduced from their long-continued agony. Surgeons are coming more and more to favor excision of the ganglion as the primary operation and with this change of opinion the author is in sympathy.

V. Pleth (Am. Jour. of Surg., May, 1919) reports uniformly good results in fifty cases of Tic in which he performed cervical sympathectomy with or without deep and superficial injections of alcohol. Apparently it is the superior ganglion which he attacks. In some cases alcohol injections are used to obtain immediate results as the full benefit from the sympathectomy is not obtained until three months or more have elapsed.

CHAPTER V

PLASTIC OPERATIONS ON THE EXTERNAL EAR

The external ear when very large or very projecting may be operated on for cosmetic reasons.

Macrotia.—The pinna is uniformly enlarged but does not project outwards unnaturally. Make the incision AB (Fig. 60) through the whole thick-

FIG. 60.

FIG. 61.

ness of the pinna. Pull the upper segment of pinna over the lower segment to see how much tissue must be removed in order to correct the deformity (Fig. 61). Make a cut from D to B and remove the overlapping triangle

FIG. 62.

FIG. 63.

of tissue DBC. The edge of the pinna at D does not correspond with the edge of the pinna at A, therefore cut away a wedge-shaped segment of pinna DEB (Fig. 62) and so permit the point D to be brought out to the point A. With sutures introduced alternately from the outer and inner side of the ear, unite the edge DEB to the edge AB. Instead of lengthening the wound edge DB, it might be possible to shorten the edge AB by cutting out the wedge of tissue XYZ (Fig. 62).

(A) Plastic Restoration of Lobule.—The lobule of the ear may be absent congenitally or may have been removed by accident or for disease. If removed for disease it may be replaced at the primary operation or later.

Gavello's Operation.—Step 1.—Freshen the stump of the lobule. Apply pressure with a hot pad to stop bleeding. Retract the stump upwards.

Step 2.—Reflect, and fold on itself the flap ABC (Fig. 63). With sutures keep the two raw surfaces of the flap together.

The flap or new lobule must be one-third larger than the normal lobule; this to allow for shrinkage.

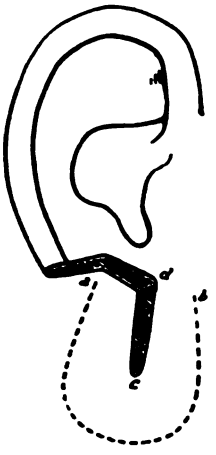


FIG. 64.—(*Laurens.*)

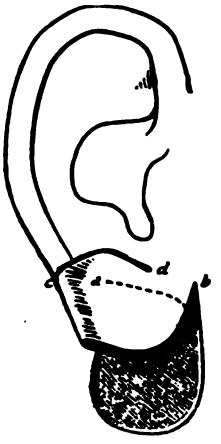


FIG. 65.—(*Laurens.*)

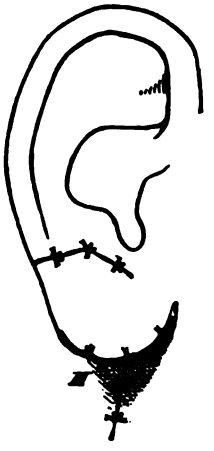


FIG. 66.—(*Laurens.*)

Step 3.—Suture the upper edge of the new lobule to the vivified stump of the old lobule.

Step 4.—Close the wound in the neck either by sliding of skin or by grafts.

(B) Coloboma of Lobule.—A part of the lobule may be absent either congenitally or as the result of accident, usually the result of necrosis following piercing of the lobule with dirty instruments. Nelaton's method of operating will be easily understood by glancing at Figs. 64, 65, 66.

SYNECHIA OF LOBULE

Occasionally, instead of hanging in the normal fashion the lobule is adherent to the body through its whole length. The deformity may be annoying. The following method is suggested for correction of the synechia: Mark the line along which the lobule ought to be separated. In front of the ear raise the flap X (Fig. 67), having its base corresponding to the above-mentioned line and attached to the ear. Behind the ear elevate the flap Y, having its base or pedicle attached to the neck (Fig. 68). Divide the lobule along the line AB. Attend to hemostasis. With the flap X cover the wound now

existing on the new inner edge of the lobule. With the flap Y cover the corresponding wound in the neck. Fix the flaps in position with sutures.

FIG. 67.

FIG. 68.

FIG. 69.—(*Laurens.*)

FIG. 70.—(*Laurens.*)

PROMINENT EARS

Instead of lying parallel to the head the auricles may stand out more or less at right angles to the head. The deformity, especially when the ears are large, is considerable and may have an injurious influence on the patient's career. There are several methods of correcting the deformity.

Method A.—The deformity is not of high degree. There is little or no macrotia, there may be, as in Bacon's case, some microtia. Remove the whole thickness of the skin from the area abcd (Fig. 69). Take away more skin from the auricle than from the mastoid region. Suture the edge adb to the edge acb (Fig. 70).

Method B.—A portion of the skin and an ellipse of cartilage may be removed (Fig. 71), and the wound closed (Fig. 72). The result is, however, not satis-

FIG. 71.—(*Payr.*)

FIG. 72.—(*Payr.*)

FIG. 73.—(*Payr.*)

FIG. 74.—(*Payr.*)

factory. Payr recommends the excision of a sickle-shaped portion of cartilage (Fig. 73). This gives better results.

FIG. 75.—(*Payr*)

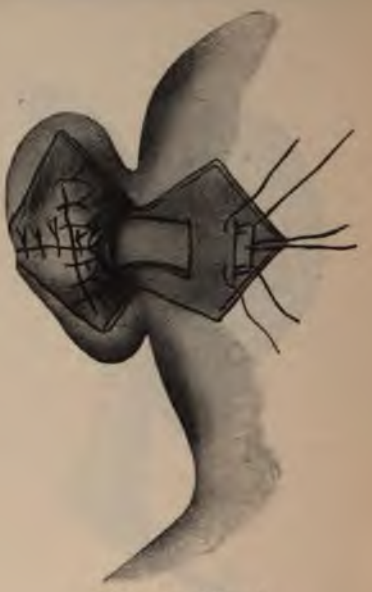


FIG. 76.—(*Payr.*)

FIG. 77.—(*Payr.*)

Method C (Payr's Operation).—Payr found ("Archiv für klin. Chir.," lxxviii, 918) that the results from Method A were good at first but that the spring-like action of the cartilage of the ear caused stretching of the scar and some recurrence of the deformity. In cases of great deformity he operates as follows:

Step 1.—Remove the skin from the areas I and II (Fig. 74). Make the incisions a–a, b–b, c–c, down to, but not into, the cartilage. Reflect the flaps abab and aacc.

Step 2.—From the most prominent part of the concha posteriorly make two parallel incisions about $\frac{3}{8}$ inch apart, through the cartilage out to the free margin of the auricle. Do *not* injure the skin covering the anterior surface of the cartilage. Elevate and turn back the flap of cartilage (Fig. 75). From the cartilage above and below the transverse wound remove sickle-shaped portions of cartilage (Fig 75).

FIG. 78.—1. Helix. 2. Antihelix. 3. Fossa of helix. 4. Fossa of antihelix.

Step 3.—With sutures close the wounds in the cartilage (Fig. 76).

Step. 4.—In a convenient location make two parallel incisions through the mastoid periosteum and elevate a bridge of periosteum. Pull the flap of cartilage under the periosteal bridge and suture it there (Figs. 76 and 77).

Step 5.—Close the wounds aa, bb, cc with sutures (Figs. 74 and 77). Unite the edges of the denuded area I to the edges of the denuded area II (Figs. 74 and 77). This operation corrects both the macrotia and the malposition. If the ear is not much enlarged and there is marked malposition the anchoring flap of cartilage may be made narrow and the sickle-shaped resection of cartilage may be omitted.

FIG. 79.—(*Luckett, Surg., Gyn., Obstet.*)

Method D.—Luckett ("Surg., Gyn., Obst.," June, 1910) considers that in prominent ears the deformity is due to absence or insufficient development of the antihelix (Fig. 78), the cavity of the concha being continuous with that of the helix. To form an antihelix Luckett operates as follows:

Step 1.—On the inner or posterior surface of the auricle make a crescentic incision through the integument opposite the line of the intended new antihelix. Remove the inscribed integument. Dissect the edges of the skin free from the cartilage and retract them. Remove a similar crescentic segment from the cartilage. The amount of

cartilage removed depends on the extent of the deformity. Do *not* buttonhole the skin on the anterior or external side of the ear when removing the cartilage.

Step 2.—Close the wound in the cartilage by Lembert sutures so as to invert the edges (Fig. 79) and form an antihelix.

Step 3.—Close the skin wound with horse-hair sutures.

Hematoma Auris. Othematoma. Cauliflower Ear.—Don H. Palmer (Northwest Med., Dec., 1913) operates with good results in this deformity as follows: Sterilize the external ear and surroundings by any good method without iodin. Plug the external auditory meatus with cotton. Make an incision over the most prominent part of the swelling into the hemorrhagic cavity. With curette or fine gouge remove all clots, new-formed cartilage or bone. Gently scrape the anterior surface of the old cartilage until it is smooth. Close the incision except for a small opening which will just admit a Eustachian catheter connected with a small Pynchon pump. With the pump remove all accumulated blood; the suction compels approximation of the skin, perichondrium and cartilage. Dry the skin. Put a fresh, dry plug of non-absorbent cotton in the external auditory canal. Apply sterile vaseline generously to both surfaces of the ear and to the surrounding parts. Place a cardboard mould around the ear and fill it with plaster-of-Paris cream so that the ear is completely encased in the plaster through which the Eustachian catheter projects with the connected pump working continuously.

As the plaster hardens rotate the catheter sufficiently to permit its easy removal. As soon as hardening is complete remove the catheter; the track left by its removal, permits drainage. Hold the plaster cast in place by bandages. After about ten days remove the cast by fragmentation.

CHAPTER VI

EMPYEMA OF THE ANTRUM OF HIGHMORE

INTRANASAL OPERATION

Cocainize the lower meatus of the nose. Seat the patient with his head well thrown back. Introduce a stout, curved trocar and cannula through the nostril to a point immediately under the inferior turbinated bone, *i.e.*, to a point in the highest portion of the inferior meatus of the nose. Before this can be done it may be necessary to remove part of the inferior turbinate bone. Turn the trocar so that its point touches the outer wall of the nose (inner wall of the antrum) at right angles. Push with steady force, outwards so as to make the trocar enter the antrum. Wash out the antrum with warm water or a mild antiseptic. Do *not* use peroxide of hydrogen; it may spread infection. Remove the trocar. No dressings are required. The trocar used ought to be large enough to leave a more or less permanent opening.

Alveolar Route.—Provide a drill about the size of a No. 16 French sound. Provide one or more metal drainage tubes about ¾ to 1 inch long, provided with a flange to prevent their slipping into the antrum. Provide a nozzle which can slip into the drain and permit of irrigation.

Examine the teeth. If a carious tooth is found it is probably the cause of the empyema, and must be extracted. (The teeth at fault may be the first premolar or the first or second molars.) Through the tooth socket drill a hole upwards and backwards (never inwards) into the antrum. Remove the drill, substituting a drainage tube. Irrigate daily through the tube.

Never sacrifice a healthy tooth to gain access to the antrum by this route. The drainage tube used ought to fit the drill hole snugly and so have no tendency to fall out.

Radical Operation.—This method is based on the obsolete method of drainage through the canine fossa. Administer a general anesthetic.

Step 1.—Retract the upper lip upwards and outwards. Make an incision to the bone from the maxillary tuberosity to a point immediately below the nares, high up above the line of the reflection of the mucosa from the alveolus to the cheek. Attend to hemostasis by temporary pressure. Pull the upper edge of the wound upwards with a retractor.

Step 2.—With a periosteal elevator expose the whole outer wall of the antrum. Do not injure the infraorbital nerve. Open the antrum with a chisel, enlarge the opening with rongeur forceps. Cleanse out any pus and blood which may be present. Attend to hemostasis by temporary packing gauze.

Step 3.—Explore the antrum. If the disease is catarrhal merely wash the cavity. If granulation tissue is present in quantity remove it by scraping it away with pledgets of gauze or with a curette used gently. If necrosed bone is present remove sequestra and diseased bone. Occasionally sinuses leading through the alveolus to the mouth require excision (Laurens) through a vertical cut reaching from the primary incision to the alveolar margin. Examine the inner wall of the sinus carefully behind the normal opening into the nares, because ethmoidal disease may cause necrosis here, and unless the ethmoid trouble is treated a cure may be prevented.

Step 4.—Provide permanent drainage for the sinus as follows:

With chisel, forceps, etc., remove the lower ⅔ of the nasal wall of the sinus. This means removing the lower turbinate bone as well. Bleeding will be free but is easily stopped by gauze pressure. Be sure that no crest of bone remains between the nasal and antral floors (Laurens). Pack the cavity with gauze brought out through the nostril.

Step 5.—Close the wound in the mouth with sutures.

Remove the pack in twenty-four or forty-eight hours. After this keep the parts as clean as possible without greatly disturbing the patient.

P. L. Friedrich's Radical Operation.—Make an incision down to the bone, skirting the ala of the nose in the natural groove of this region. Expose the outer and lower angle of the pyriform opening. With the elevator separate the soft parts and periosteum together from the outer surface of the superior maxilla; it may be necessary to make an incision to the bone from the middle of the primary incision downwards and outwards for about three-fourths of an inch. With the elevator separate the muco-periosteum of the outer wall of the nose from the edge of the pyriform opening backwards for about one inch. A fair area of both the facial and nasal walls of the lowest portion of the antrum are exposed by the above means. With chisel and rongeurs,

beginning at the lower and outer angle of the pyriform opening, cut away the bony walls (both facial and nasal) of the antrum. In doing this, part of the inferior turbinate bone is removed.

Friedrich's operation gives very free access to the antrum and permits proper treatment both of the antrum and of any fistulæ leading from it.

The intranasal and alveolar methods of treating empyema of the antrum are suitable in cases of catarrhal inflammation, or where dental disease is the primary cause of the trouble. When the disease resists drainage for two or three weeks the probabilities are that osteitis, necrosis or some granulomatous condition is present and only the radical operation will avail.

CHAPTER VII

OSTEOPLASTIC EXPOSURE OF THE ORBIT

Frankes' Modification of Kronlein's Operation.—This operation is of value in the exploration of, and removal of tumors from, the orbit when it seems possible to preserve the eye.

Step 1.—Below the level of the eyebrow make an incision corresponding to the external half of the upper margin of the orbit. Continue the incision downwards along the outer margin of the orbit to a point near the lower orbital margin. From this point cut backwards on the malar to the middle third of the zygoma.

FIG. 80.—Osteoplastic exposure of the orbit.

Step 2.—(*a*) Subperiosteally divide the zygoma near its middle. (*b*) Beginning at the upper and outer part of the orbital rim, subperiosteally divide the outer orbital rim backwards and downwards to the inferior orbital fissure (Fig. 80). This is best done with a chisel. (*c*) Beginning at the lower and outer part of the orbital rim, subperiosteally divide the malar backwards to the inferior orbital fissure and to the origin of the masseter.

Step 3.—Reflect the bone flap thus formed. Remove any portions of the external orbital plate which obstruct, and so expose the orbital fat.

Step 4.—Do whatever may be necessary to the orbital contents.

Step 5.—Replace the bone flap. Suture the skin. Suture of the bone is unnecessary.

CHAPTER VIII

EXCISION OF UPPER JAW

Resection of the Alveolus, Schlange's Method.—This is usually called for because of tumors. Small tumors may be removed by the methods recommended in excision of the alveolus of the lower jaw. When much of the alveolus is involved and perhaps part of the palate, Schlange operates as follows: Provide three or four gouges with blades 1 to 2 inches wide. Tampon the nostril on the affected side. If necessary in order to obtain free access, split the cheek by a curved incision running upwards and outwards from the angle of the mouth. Open the jaws widely with a gag. Retract the cheek and upper lip thoroughly. Beginning posteriorly and as remote as possible from the disease drive the gouges one after the other vertically upwards through the alveolar and palatal processes into the antrum. Leave each gouge undisturbed *in situ;* this is of great importance because removal of the instrument would at once be followed by serious bleeding. "When the horizontal portion of the superior maxilla has been thus divided by three gouges the part to be removed is held in place merely by the anterior wall of the antrum. With the fourth gouge quickly divide this connection and exerting slight leverage on the chisels remove them and the separated bone together. Before the gaping wound has time to bleed pack it with a tampon or large sponge which has been held in readiness. The operation can be carried out in a few minutes and with almost no loss of blood." When much of the alveolus is removed from a young and growing patient great deformity of the jaw and teeth may be expected unless the defect is properly filled by a suitable prosthesis.

FIG. 81.—A, B, C, D, Weber's incision; P, V, Velpeau's incision.

Many incisions have been devised to expose the superior maxilla. Probably the best are those of Weber (A, B, C, D, Fig. 81) and Velpeau (V, P, Fig. 81).

Weber's Incision.—Beginning immediately below the inner angle of the eye, make the incision B, C, D, which skirts the ala of the nose and divides the upper lip in the middle line. From the point B (Fig. 81) make the curved incision (B, A, Fig. 81) which follows the lower margin of the orbit. Reflect outwards the flap outlined by the complete incision.

Velpeau's Incision.—This incision is very similar to that of Syme. Beginning at the angle of the mouth, make the incision, P, V (Fig. 81), through the whole thickness of the cheek. The cut runs obliquely upwards and outwards from the angle of the mouth for such a distance as will permit of exposure of the superior maxilla by reflection of the cheek upwards and inwards. This incision is not as good as Weber's.

Separate the periosteum covering the floor of the orbit from the bone. Gently lift the orbital contents upwards with a flat retractor. With a bone

forceps or Gigli saw divide the malar bone and with it part of the orbital floor at the point Z (Fig. 82). In the same manner divide the nasal and orbital processes of the superior maxilla at the point X. Open the patient's mouth and with a knife make an incision through the muco-periosteum of the hard palate, parallel and close to the middle line. Continue this incision forwards and then upwards through the muco-periosteum covering the alveolus to the nasal aperture. With bone forceps, Gigli or finger saw divide the hard palate and alveolus along the line of the mucoperiosteal incision. With knife, or better with scissors, separate the soft palate from the hard palate on the side being excised. Seize the superior maxilla with lion-jawed forceps and forcibly remove it with a twisting motion. Any undivided strands of tissue may be severed with scissors. The internal maxillary artery will generally be found bleeding vigorously in the depth of the wound. It should be seized with forceps and ligated. Oozing is stopped by pressure with gauze pads wrung out of very hot water. Pack the wound with iodoform gauze. Replace the flap of soft structures over the packing and suture it in position.

FIG. 82.—Excision of upper jaw.
X, Y, Z. Usual lines for division of bone. P, Q. Section may be made here instead of at Z, when disease is extensive.

The after-treatment consists in having the patient lie on the side operated upon or sit up in bed or a chair as early as possible. This is to avoid danger of pneumonia. The mouth must be kept clean. Closure of the wound usually takes place rapidly. When recovery has taken place, consult a good dentist with regard to the use of an artificial palate.

Keen notes that sarcoma of the upper jaw often extends through the infundibulum into the frontal sinus. This extension must be looked for and removed. Extend the incision C, B (Fig. 81) upwards to the nasal side of the inner canthus over the frontal sinus. Remove with a smaller rongeur the anterior wall of the infundibulum and of the frontal sinus; wipe away the tongue-shaped process of the sarcoma with a gauze pad.

W. J. Hearn, Matas, and others always ligate the external carotid before excising the jaw. The former surgeon finds in doing so that he always exposes some enlarged glands which require removal. Matas emphasizes the importance of ligating the external carotid high up, well above the bifurcation, otherwise there is danger from cerebral embolism.

A. H. Ferguson's operation, suitable in cases where the skin is not involved.

1. Place the patient with head hanging over a sand-bag.

2. Make an incision about one-half inch long over the nasal process of the superior maxilla; through this, with an osteotome, divide the bony process.

3. Repeat Step 2 over the junction of the superior maxilla and the malar and divide the bone.

4. Cut through the alveolar process and the hard palate. Save as much of the soft palate as possible.

5. With elevator or forceps evulse the jaw and pull it out through the mouth. Pack the cavity with iodoform gauze.

BARDENHEUER'S OPERATION FOR PARTIAL EXCISION OF THE UPPER JAW AND IMMEDIATE PLASTIC REPAIR

By means of the incision A, B, C (Fig. 83) the flap C, E, D is reflected and the jaw and tumor exposed. By means of saw, bone forceps, and scissors

FIG. 83.—(*After Bardenheuer.*)

FIG. 84.—(*After Bardenheuer.*)

the jaw is partially excised, the object being to remove the tumor and with it a safe margin of healthy bone. Bleeding is arrested by ligature, hot water and sponge pressure. The incision F, G, H (Fig. 84) outlines a skin-flap (hairless) in the pedicle of which is a portion of the skin of the upper eyelid as well as the whole eyebrow. The flap is turned (epidermis inwards) into the position F, I, H, and there sutured. The flap C, E, D is now turned back into its old position and there sutured. Most of the wound F, G, H is covered by Thiersch's grafts. After the lapse of two weeks the pedicle of the flap F, H, I is divided and the eyelid and eyebrow contained in it returned to their normal position. The wound left where the pedicle was divided must be trimmed and closed. The result is seen in Fig. 85.

EXCISION OF SUPERIOR MAXILLA WHERE THERE IS TUMOR INVOLVING BOTH THE BONE AND THE SKIN

Make the incision A, B, C (Fig. 86). Isolate the tumor from the rest of the skin by the incision D, F, E, which joins A, B and C at the points D and E. Reflect the flap A, D, E, C towards the opposite side of the body (Fig. 87). Reflect the skin at B towards the ear so as to expose the zygoma and the frontal process of the malar. Divide the bones as shown in the dotted lines in Fig. 87. Remove the tumor and superior maxilla as in the classical

operation for excision of the upper jaw. Pack the wound with iodoform gauze. Replace the flaps and suture them in position.

FIG. 85.—(*After Bardenheuer.*)

FIG. 86.—Author's method of excising upper jaw for disease involving the skin.

EXTENSIVE EXCISION OF UPPER JAW

The younger König in very extensive disease of the upper jaw necessitating removal of the floor and outer wall of the orbit recommends the following operation:

1. Ligate the external carotid between the origin of the superior thyroid and lingual arteries. This step is simple, harmless, and very useful.

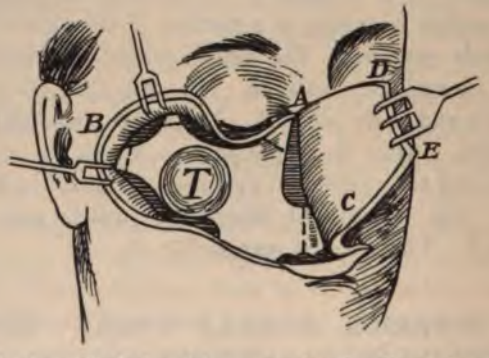


FIG. 87.—Author's method of excising upper jaw for disease involving the skin.

2. Expose the bone by Velpeau's incision. Remove the disease.

3. Recognize and expose the temporal muscle in the outer part of the wound. At the level of the coronoid process and about 1½ finger-breadths from its anterior margin split the muscle upwards and downwards. With a chisel divide the ascending ramus of the lower jaw along the line in which

the muscle was split. The result of the above is to provide a flap, consisting of temporal muscle and bone, attached above to the skull and free below (Fig. 88).

FIG. 88.—F. König's operation.

FIG. 89.—Author's method of excising rodent ulcer.

4. Turn this flap inwards and unite its free extremity to the remains of the frontal process, so that a firm floor is provided for the orbit and the eye is kept in place.

5. Complete the operation by closure of the skin-wound and packing with iodoform gauze.

RODENT ULCER

As a type of operation for rodent ulcer an example may be taken where the disease involves the malar, the superior maxilla, and to a moderate extent the orbit.

FIG. 90.—Author's method of excising rodent ulcer.

1. Make an incision around the disease, and distant from it ½ inch (Fig. 90).

2. Leaving the diseased tissue undisturbed, reflect the soft parts all around it from the bones so as to lay bare to touch the upper margin of the orbit, the external angular process of the frontal bone, the temporal process of the malar (Fig. 90), the external anterior surface of the superior maxilla above the alveolar process, and the nasal bone on the affected side. As hemorrhage occurs, it must be arrested *at once*.

3. With bone forceps or chisel cut through the bones as shown in Fig. 91. Bone incision A (Fig. 91) penetrates the antrum of Highmore.

4. Separate the orbital contents from the roof of the orbit and divide the optic nerve.

It is now easy to remove the disease surrounded by a fairly large zone of healthy tissue. The cavity is packed with iodoform gauze. After the lapse of about ten days endeavors may be made to lessen the deformity which has been produced. As the cavity is largely lined by mucous membrane, it is proper that an endeavor should be made to provide its new covering with an epidermal surface internally.

FIG. 91.—Excision rodent ulcer.

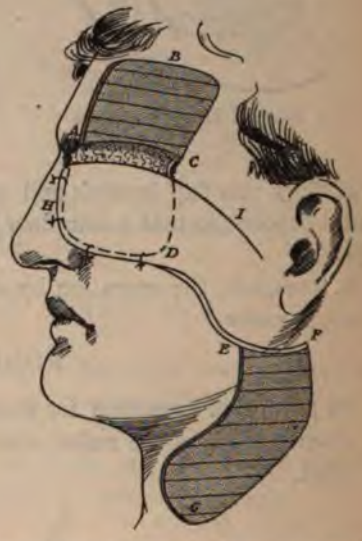


FIG. 92.—Plastic repair after excision rodent ulcer.

Type of Operation to Repair the Deformity.—On the *hairless* forehead make the incision A, B, C, Fig. 92, so as to obtain a flap, A, C, D, of size and shape suitable to provide an epidermal outer and anterior wall to the cavity left by operation. The base (A, C) of the flap is a little above the orbit and ought to extend beyond the orbit on one side or the other so as to have plenty of nourishment. The flap is now turned down so that its epidermal surface faces inwards, its raw surface outwards. The edges of the flap are stitched with catgut in the position A, C, D (Fig. 92). From the neck the flap E, F, G is dissected up and sutured in the position F, E, H, I. The raw surfaces A, B, C and E, F, G are lessened in size by sliding their edges centripetally and there suturing them. Any parts not covered by skin are now grafted by Thiersch's method.

After the lapse of two weeks, if everything has gone well, the pedicles of the flaps A, D, C and H, I, E are divided and their remnants turned back into their old positions. A certain amount of trimming and suturing must be done at the margins of the now repaired deformity.

Note.—In the original operation when the bone incisions are being made it is wise to divide the nasal bones last, so as to avoid the entrance of blood into the nose. The complete dissection of the soft parts before attacking the bones ensures that most of the bleeding will have been attended to before any of the facial cavities have been opened. Should the patient's strength warrant, the reparative work might be done at the same sitting, but the disease generally affects the old and debilitated.

Osteoplastic Resection of Upper Jaw (Kocher).—Suitable for the removal of nasopharyngeal and retropharyngeal neoplasms—*e.g.*, sarcomata, etc.

Preliminary ligation of both external carotid arteries may or may not be practised. Place the patient in Trendelenburg's position. This renders preliminary tracheotomy unnecessary.

Step 1.—Split the upper lip near the middle from the nostril to mouth. On each side divide the buccal mucosa at its line of reflection from cheek to alveolus. Only divide the mucosa sufficiently to permit the performance of Step 2.

Step 2.—With a chisel divide the anterior-external wall of the antrum from the nose outwards and backwards above the alveolus. This opens the antrum.

Step 3.—With a wide chisel (better osteotome) of thin steel divide the alveolus and hard palate close to the middle line. With strong sharp hooks pull the halves of the upper jaw apart, pushing the vomer to one side and dividing any nasal mucosa which hinders. If necessary divide the soft palate. Remove any of the turbinated bones which obstruct.

Step 4.—Free access to the base of the skull is now possible. Remove the tumor *secundum artem*, using the cautery if necessary.

Step 5.—Replace the halves of the jaw and fix them by a suture (wire or silk) penetrating the alveolus. Suture the soft palate if it has been divided.

Step 6.—Apply iodoform gauze packs to the bed from which the tumor was removed bringing the ends of the pack out through the nose.

Partsch's Method.—(Beiträge z. klin. Chir., xci, 555).—Place the patient on a table which is slightly inclined to one side and has its lower end moderately elevated. The patient's neck is supported on the edge of the table (not hanging as in Rose's position). A general anesthetic is administered through a tube. The external carotid arteries may be ligated or hemorrhage may be lessened locally by the use of adrenalin.

Make an incision above the alveolus of the upper jaw from the second molar on one side to the second molar on the other side. Retract the soft parts upwards and open the nasal fossæ by freeing the mucosa at their anterior orifices. With a thin chisel divide the septum nasi along the floor of the nose. Divide the anterior and external walls of the antrum of Highmore at the level of the antral floor. Do this on both sides as far back as the maxillary tubercles. The alveolus and the palatal vault can now be pushed down as a flap the hinge of which corresponds to a transverse line passing through the posterior extremities of the maxillary body. This gives very free access to the nasopharynx without interfering with the palatine arteries. When the operation is finished the flap is easily replaced and secured by some stitches through the mucosa.

Reinhardt ("Zentralblatt für Chir.," May 9, 1908) has collected fourteen cases in which this operation has been performed without a death.

Exposure of the Base of Skull by Temporary Resection of the Palate.—C. Hofmann's method ("Zentralblatt für Chir.," 1910, No. 24).

Step 1.—Make an incision through the mucosa of the palate from the premolar tooth on the right side to a corresponding point on the left side. Nearly at right angles to the above incision make a cut immediately to the inner side of the alveolus (on the right or left side of the palate, according to the location of the tumor in the nasopharynx). This incision extends backwards to the edge of the soft palate dividing the muco-periosteum covering the hard palate and the whole thickness of the soft palate.

Step 2.—With a chisel divide the bone of the palate corresponding to the incision made in Step 1. With an elevator raise the palate and reflect the flap of bone and soft parts, fracturing the bone in the pedicle of the flap. While this is being done the nasal septum must necessarily be either fractured or divided.

Step 3.—After removal of the tumor from the nasopharynx replace the flap and fix it with a few sutures. Hofmann states that the flap tends to stay in position and that the whole operation is easy.

CHAPTER IX

LOWER JAW—RESECTION

I. RESECTION OF THE ALVEOLAR PROCESS

Incise the muco-periosteum around the portion of bone to be excised. If the portion to be excised is small, its removal may be effected with rongeur forceps or with the chisel and mallet. In using the chisel the surgeon should hold the instrument in one hand, support the jaw with the other, and let his assistant manipulate the mallet. When the excision is to be more extensive, one may with a finger saw make a vertical incision through the alveolar process in front of, and another behind, the portion to be removed, and join the lower ends of the vertical incisions by a horizontal one cut with a chisel or a saw operated by a surgical engine.

FIG. 93.

II. PARTIAL RESECTION OF THE HORIZONTAL RAMUS

Make an incision through the skin down to the bone along the inferior edge of the jaw. Separate the soft parts from the inner and outer surfaces of the jaw. If the operation is done for necrosis, preserve the periosteum; if for tumor, sacrifice it. Divide the jaw by vertical incisions made with the Gigli wire or the finger saw, in front of and behind the disease. If teeth are present at the lines of vertical incision, they must be removed before the saw is applied. Remove the segment of bone between the vertical cuts. Whenever the nature and extent

of the disease permit, it is important to leave the lower edge of the jaw *in situ* (X, Y, Fig. 93), as then the continuity of the maxilla is maintained. To accomplish this, the vertical bone incisions do not completely divide the jaw, and the excision is completed with the chisel. It is difficult to use a saw on the lower jaw. To cut accurately with a chisel is no easy task and the bone is very liable to fracture. A good method to secure precision and safety is as follows: After incising the muco-periosteum at a safe distance from the tumor, bore a series of holes about ¼ inch apart all around the portion to be removed. When this has been done it is easy to complete the excision with rongeur forceps or chisel. If possible, suture the mucous membrane of the floor of the mouth to that of the cheek. Close the cutaneous wound after providing for drainage.

III. RESECTION OF ONE-HALF OF THE INFERIOR MAXILLA

Transfix the tongue with a stout thread for purposes of traction. Make a vertical incision in the middle line through the chin, beginning a little below the edge of the lower lip and ending on the lower edge of the jaw. Do not include the margin of the lower lip in the cut unless compelled to do so by the size of the tumor.

From the lower end of the vertical incision make a cut along the inferior edge of the jaw to its angle. If necessary, continue the cut up the posterior edge of the ascending ramus of the jaw to a point not less than one finger-breadth below the lobe of the ear. Before the facial artery is divided it should be ligated.

With periosteal elevators, scissors, and knife separate the soft parts from the outer side of the bone to be removed. If the operation is for the removal of a tumor, sacrifice the periosteum. Choose the line in which to divide the bone anteriorly, extract any teeth which may be in the way, and divide the bone with the Gigli wire or finger saw after the soft parts have been separated from both sides of the bone along the line of section. Pull the jaw downwards and outwards and separate the soft parts from its inner surface (mylohyoid, geniohyoid, and internal pterygoid muscles, submaxillary gland, etc.). Pull the jaw downwards, expose the coronoid process, and divide its attachments to the temporal muscle. It may save time and be easier to cut through the coronoid process with bone forceps than to separate the temporal muscle from it.

By blunt dissection separate the masseter muscle and the parotid gland from the ascending ramus. With a twisting movement directed downwards and outwards tear the head of the bone out of its bed and the active part of the operation is completed. Attend to hemostasis. If possible, suture the mucous membrane of the floor of the mouth to that of the cheek. Close the external wound after providing for drainage.

The after-treatment consists in endeavoring to keep the mouth clean by means of frequent washing with mild antiseptic solutions, in nourishing the patient, and in encouraging him to sit or walk about at as early a date as possible.

When, after any operation in which one-half of the inferior maxilla or a segment of it is removed, deformity results and the teeth of the lower jaw no longer articulate with their fellows above, some surgeons or dental surgeons have managed by a long and painful process to push the fragments of the lower jaw back into their normal position after healing has taken place and have maintained the position by means of a plate or of bridge-work.

Sinclair White ("Brit. Med. Journ.," Nov. 27, 1909), in removing two inches of the lower jaw for a tumor preserved the periosteum of the lower edge of the excised segment. "The resected surfaces of the lower jaw were pierced with a drill to the depth of ¾ inch. The drill hole in the body was horizontal and placed near its lower margin, so as to miss the teeth roots; that in the ramus was vertical and somewhat posterior to the mandibular foramen. The ends of a suitable length of stout silver wire were jammed tightly into the drill holes, and the wire completely covered by suturing together the mucous membranes of the cheek and the floor of the mouth over it. The diagram (Fig. 94) indicates the position and curve of the wire.

FIG. 94.—Metal splint used after resection lower jaw. (*Sinclair White.*)

FIG. 95.—Metal splint used after resection lower jaw.

A small drain tube was placed in the neck end of the wound and retained for forty-eight hours, and the mouth was rinsed frequently with hydrogen peroxide solution. A little pus formed in the track of the tube, but the wound in the mouth healed quite kindly.

"At the present time, except for the skin scar, there is absolutely no external deformity. He can open his mouth almost to the full, and when the jaws are closed the teeth on the right side meet accurately those in the corresponding side of the upp er jaw. He is able to bite soft things, and has to be restrained from attempting greater masticatory feats."

Partsch,* after removing a segment of the lower jaw, keeps the ends of the bone in correct position by means of a perforated metal plate united to the bone by a couple of wire stitches. (See Fig. 95.) The metal plates are protected with rubber tubing, and the mucous membrane of the floor of the mouth and of the cheek are sutured together *below* the metal plate so that the latter lies exposed in the oral cavity. As soon as a proper dental apparatus or plate can be made and properly fitted, the temporary metal plates are removed. Berndt, in cases where half the inferior maxilla has been removed, replaces it with an apparatus of celluloid. After the bone has been removed he sutures the mucous membrane of the floor of the mouth to that of the cheek, packs the wound, and lays silkworm-gut cutaneous sutures in position but does *not* tie them. After the lapse of about ten days he takes a celluloid ring pessary, softens it by boiling,

*"Archiv f. klin. Chir.," lv, 746.

moulds it to the proper shape, and puts it into the wound so that one end is in the glenoid cavity while the other rests against the sawed surface of the remnant of the lower jaw. He next closes the skin-wound and ties the sutures already in place, thus completely covering the celluloid apparatus. Berndt reports that slight suppuration often takes place anteriorly from irritation to the sawed surface of bone, but that if a small portion of the celluloid is then cut away by forceps, a little fibrous tissue forms between the bone and the foreign body, and the wound heals. One patient* seven months after operation claimed to have celebrated Christmas by cracking nuts with his jaw, one-half of which was celluloid, and to have suffered no ill consequences.

By an incision made through the skin below the jaw Macewen has implanted a piece of rib between the fragments of jaw. Of course no communication existed between the site of implantation and the mouth. The implanted bone was obtained from a rib near the axilla. The result was perfect.

FIG. 96. (*Stillman.*)

Macewen's method has been successfully carried out by a number of surgeons. Clarence McWilliams found that if the transplant was entirely deprived of periosteum it became absorbed. This does not agree with Macewen's observations. Stanley Stillman ("Annals Surg.," July, 1912) uses Murphy's silver-wire girder (Fig. 96) to hold the remnants of the inferior maxilla in good position until healing has advanced far enough to permit bone implantation. He finds the silver cannot be left *in situ* permanently but that when it is removed the scar tissue keeps the bones in a useful position—so useful that the patient may prefer not to have the transplantation made.

H. Nimier† gives an admirable description of Martin's prosthetic apparatus

*"Archiv f. klin. Chir.," lvi, 210.
†"Traité de Chir." Delbet and Le-Dentu, v, 793.

suitable for use after even very extensive excision of the inferior maxilla. He says: Provided with a segment of maxilla formed out of hard rubber, moulded in advance to represent the bone to be excised, the surgeon cuts and fashions it so as to fit between the remaining portions of the bone and to reëstablish the exact shape of the inferior maxilla. Two small platinum plates at each end of the apparatus are attached to the bones by screws, and, acting as *fish-plates* between the bone and the substitute for bone, keep the latter in position. If much of the ascending ramus has been removed, the anterior portion of the apparatus is fixed to the remnants of the coronoid process, while that portion corresponding to the articulation is left unattached. To assure solidity in such cases it is necessary to attach the apparatus to the palate by a moulded plate. On the upper edge of the apparatus a band of hard rubber roughly simulates the teeth. It is necessary to disinfect the tissues in which the foreign body is implanted, and for this purpose the apparatus is perforated in various directions, so that irrigation is easy. Fig. 97 shows apparatus used after an almost complete excision of the lower jaw. The above description applies to the implantation of a temporary splint. When cicatrization is complete, a permanent one replaces it. The permanent apparatus is merely a more elaborate edition of the temporary. In cases of extensive excision the apparatus may be introduced in two parts, which are then united by fish-plates and screws.

FIG. 97.

1. Articular process lower jaw. 2. Hard-rubber ridge representing teeth. 3. Artificial lower jaw. 4. Fish-plate uniting remnants of bone to the apparatus. 5. Fish-plate uniting the two halves of the apparatus. *c*. System of tubes for irrigation.

Such extremely ingenious and complicated prosthetic devices will rarely be available when required, and if available, must rarely be serviceable. The tissues do not tolerate foreign bodies well for any length of time, and especially mobile bodies, such as described above. They have been described here more as examples of surgical ingenuity than as practical aids.

Fractures of the Mandible or Lower Jaw.—Few recent fractures of the mandible require operative treatment. Malunion and non-union usually demand operation. When there is little or no loss of substance, wiring or plating is usually suitable. When there is considerable loss of substance, some form of bone grafting is essential. In cases of malunion with great deformity, correction of the deformity is impossible without penetrating the mouth. Under such circumstances the mobilized fragments should be wired together in spite of the inevitable infection. With the above exception all operations should be performed with the most painstaking aseptic care and without penetrating the mouth. The ideal is 'knife and fork' operating, no finger touching the wound.

1. *Wiring and Plating.*—P. P. Cole (Brit. J. Surg., July, 1918) writes "cases suitable for wiring are those in which there is little or no loss of substance. As has been pointed out, these fractures occur in the neighborhood of the angle. The posterior fragment is left free. The anterior fragment, if not edentulous,

is splinted in correct alignment. When the lower jaw is edentulous, no splint is used. Cases have been treated in this way with consistent success."

As a preliminary to operation, splinting ought to be fitted and put in place (p. 98).

Expose the bone by a suitable incision. Remove tissues interposed between the fragments. Vivify the ends of the bone. Perforate each fragment with a drill. Wire the fragments together. To do this requires free exposure of the deep surfaces of the bone and thus involves danger of penetrating the mouth. If a metal plate is used, denudation of the deep surface of the bone is unnecessary, but it is imperative to hold the fragments in accurate apposition while the plate is being applied. To avoid these troubles Cole combines the plate and wire method.

FIG. 98.—(*Cole, Brit. J. of Surg.*) FIG. 99.—(*Cole, Brit. J. of Surg.*)

2. *Bone Grafting.*

A. Free or Nonpedunoulated Graft.—When there is much loss of bone substances, there are commonly much loss of soft parts, much scar tissue and often fistulæ. Before any grafting may be attempted various plastic operations are essential. Cole's description of a concrete case is a model of clearness.

"Fig. 98 shows the condition of a patient immediately before the plastic operation was undertaken. A suitable splint was adapted to retain the fragments in correct position. A wide exposure of the area was then obtained by free reflection of the soft parts. The ends of the fragments were exposed, and the mucous membrane of the floor of the mouth was dissected up and united to the mucous membrane of the cheek. Under cover of this the bone ends were shut off from the buccal cavity, and between them was inserted a piece of decalcified bone. The soft parts on the outer aspect of the bone were brought together in such a way as to raise the corner of the mouth. Counterdrainage through a stab wound was established. The parts healed uneventfully. Nutrition was promoted by radiations and massage, and the patient is now ready

for the insertion of the graft (Fig. 99). In order to eliminate the possibility of infection from latent sources of sepsis, an interval of three months is allowed to elapse in such a case before the grafting operation is undertaken.

"The technique of this operation is as follows: Two or three days previously, upper and lower cast-metal cap-splints are cemented in place. These splints

FIG. 100.—(*Cole, Brit. J. of Surg.*)

FIG. 101.—(*Cole, Brit. J. of Surg.*)

are provided with bilateral overlapping threaded flanges, which, when fixed together by screws, determine the position of the fragments in correct alignment (Fig. 100). When the patient is on the operation table these screws are removed, allowing the mouth to be freely opened for the passage of the intratracheal

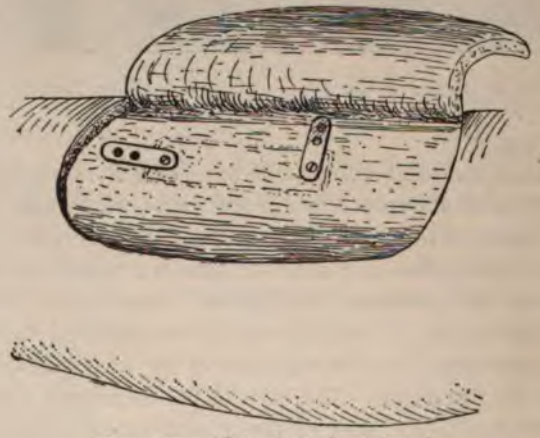


FIG. 102.—(*Cole, Brit. J. of Surg.*)

catheter. As soon as the catheter is passed, the screws are replaced. It will be noticed that the jaws so disposed are in the open bite position. This position is essential, if intratracheal methods are employed. The anesthetist is then isolated from the operation area. A curved skin incision extending well into the neck is now made, and a flap turned up to expose the site of the fracture

(Fig. 101). Bleeding vessels are ligatured and towels clipped to the skin margins. The ends of the fragments are then exposed, cleared, freshened, and shaped for the reception of the graft. The graft, taken as a rule from the tibia, is now cut, the length and shape being determined by the use of calipers and a

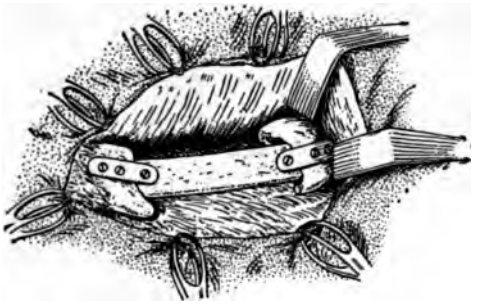


FIG. 103.—(*Cole, Brit. J. of Surg.*)

pattern cut in sheet lead. The plates are screwed to the graft before the detaching cross-cuts are made (Fig. 102). The graft with detached plates is then transferred to its destined site and fixed in the gap by two screws attaching each plate to the corresponding fragment of the fractured mandible (Fig.

FIG. 104.—(*Tainter, Jour. A. M. A.*)

103), and the wound sewn up. A similar technique is adopted when rib is employed." The graft may be obtained from any convenient bone such as the tibia or a rib. No particular attempt need be made to preserve the periosteum. Grafts from 2½ to 7½ cm. (1 to 3 in.) in length have been used.

B. Pedunculated Grafts.—Cole's Operation. (P. P. Cole, Brit. J. Surg., July, 1918, B. M. J., Jan. 18, 1919. Tainter, Journ. A. M. A., Oct. 25, 1919.)

FIG. 105.—(*Tainter, Jour. A. M. A.*)

Before operation have the dentist prepare a proper splint from impressions taken in sections and assembled on a proper articulator. Very carefully control the posterior fragment and put it in proper relation to the anterior fragment

FIG. 106.—(*Tainter, Jour. A. M. A.*)

and the upper jaw. Figs. 104, 105, 106, and 107 sufficiently describes the operation.

The Birmingham Operation (Billington, Parrott, Round, B. M. J., Dec. 21, 1918).—Preparatory treatment, often prolonged, is necessary to secure com-

plete healing of the wounds. It consists in removal of dead bone, in provision for drainage, in correction of displacements by means of dental splints, etc., and lastly in building up the general health. Unlike Cole the Birmingham surgeons remove all splints immediately before operating and do not replace them until the operative wound has healed after which the case is treated as a simple fracture.

Step 1.—Choose a point on each side of the bony defect 1 inch behind the extremity of the posterior fragment, 1 inch in front of the fractured end of the anterior fragment and about 1½ inch above the lower border of the jaw. Join these two points by a curved incision, which crosses the neck about an inch below the jaw. Turn up the flap thus outlined and with it all the soft parts covering the jaw for a distance of 1 inch from the fracture. If the mouth is penetrated completion of the operation must be put off until the wound has healed.

FIG. 107.—(*Tainter, Jour. A. M. A.*)

Step 2.—Remove all scar tissue between the fragments. With bone forceps remove a shell of bone from about 1 inch of the outer surface of each fragment. Attend to hemostasis and temporarily pack the wound.

Step 3.—Make an incision from the anterior superior iliac spine backwards along the iliac crest. With a saw, excise a segment of the crest 2 inches longer than the gap to be filled. (If a greater curve in the graft is necessary the bone between the Ant. Sup. and Ant. Inf. spines may be used.) Close the wound.

Step 4.—With forceps bevel the ends of the graft so that they can lie flatly on the prepared outer surfaces of the jaw. Place the graft in position and retain it by careful suturing of the soft parts over it. Close the skin wound with a few interrupted sutures. No drainage tube is used. Serum can escape between the sutures. Apply dressings but *no* splints.

The wound is usually sufficiently healed in two weeks to permit the use of dental splints. "Firm osseous union occurs in from two to four months, but

it is inadvisable to fit the final dentures until at least four months have elapsed and it is perhaps wiser to allow an interval of six months."

Undeveloped Lower Jaw.—When there is a marked want of development of the lower jaw there is not only present a disfiguring recession of the chin but the patient may be unable to open the mouth more than one-eighth of an inch.

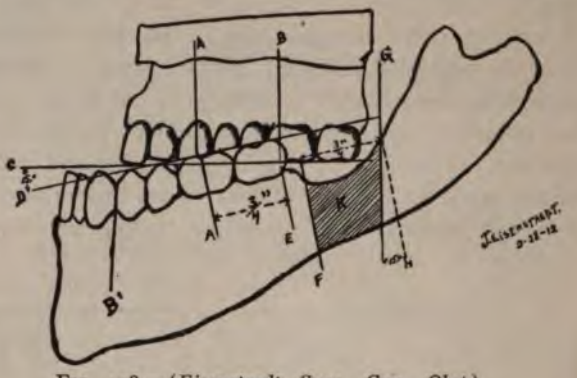


FIG. 108.—(*Eisenstaedt, Surg., Gyn., Obst.*)

V. P. Blair ("Journ. A. M. A.," July 17, 1909), has twice successfully operated as follows:

Step 1.—Make an incision about ½ inch in length in front of the lobe of each ear and retract the parotid backwards.

Step 2.—Pass a curved needle with thread through the incision, under the ramus and out through the cheek. By means of the thread pull a Gigli saw round the ramus and divide the bone horizontally.

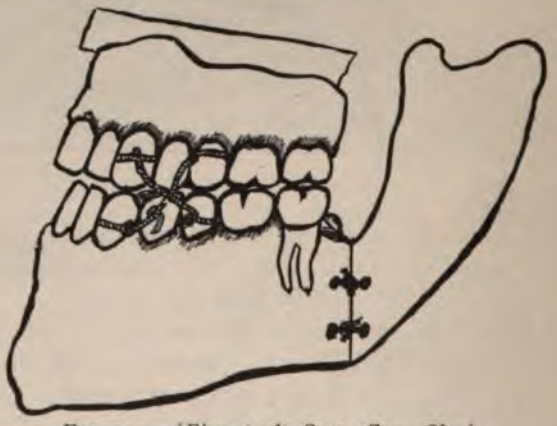


FIG. 109.—(*Eisenstaedt, Surg., Gyn., Obst.*)

Step 3.—Forcibly stretch the muscles of mastication.

Step 4.—Pull the body of the jaw forwards if possible until the lower incisors are in front of the upper. Wire teeth of the lower jaw to teeth of the upper until sufficient fixation is obtained.

Prognathism.—The lower jaw extends forwards beyond the upper so that proper articulation of the upper and lower teeth is impossible. In adolescents

orthodontic appliances are capable of greatly improving or curing the deformity; in adults the aid of operative measures becomes necessary for a cure. The surgeon must always have the aid of a good dentist or orthodontist.

Harsha and Eisenstaedt's Method (Surg., Gyn., Obst., July, 1912).—Have plaster-of-Paris models of both upper and lower jaws prepared, also skiagraphs. Make careful measurements to ascertain the shape, size and location of the wedge of bone which it is necessary to excise on each side of the lower jaw to permit proper articulation with the upper jaw. If it is necessary to extract any teeth do so long enough before operation to permit of healing and to render submucous resection possible.

Cardboard models of the lower jaw should be made on which to carry out experimental operations, as it is desirable to alter the angle of the jaw as well as to shorten the horizontal ramus. Make an incision about 2½ inches long beneath the border of the jaw. Through this separate the periosteum and muco-periosteum from the bone completely around the segment of bone it is desired to remove. Do this, if possible, without entering the mouth. With forceps and saw cut out the desired segment of bone. Unite the bone wound with wire sutures or Lane's plates. Close the skin wound, if necessary providing drainage. Carry out a similar operation on the opposite side. If necessary reinforce the union of the bone by interdental splints and wiring the teeth of the lower to those of the upper jaw (Figs. 108 and 109).

ANCHYLOSIS OF TEMPORO-MAXILLARY JOINT

The usual procedure for the operative treatment of bony anchylosis of the temporo-maxillary joint consists in mere excision of the condyle of the lower jaw. Helferich, having had poor results from the above operation, modified it slightly. His modification is founded on the fact that interposition of the muscle between the fragments is a common cause of non-union in fractures.

Helferich's Operation.—Make a vertical incision 1½ to 2 inches in length, one finger-breadth in front of the ear. Ligate the temporal artery. Push the parotid gland aside; expose the condyle and neck of the lower jaw. The temporo-maxillary joint may be indistinguishable because of anchylosis. With a chisel divide the neck of the bone at a point about ½ inch below the site of the joint. Do not preserve the periosteum. Excise the condyle and neck of the jaw above the point of section, taking away the periosteum with them. If only one joint is anchylosed, the mouth can now be easily opened. If necessary, enlarge the skin-incision upwards. Reflect a long flap from the temporal muscle, about one inch wide and with its base below. Turn the flap downwards so that its free end can be tucked into the defect left by the excision of the condyle. To turn the flap down and put it in position requires that a portion of the zygomatic arch be removed. This is easily done with rongeur or bone forceps. Fix the muscular flap in position by a few sutures of catgut. Close the wound without drainage. Apply dressings. The result obtained from Helferich's operation was most happy. Murphy's experience seems to show that a flap of fat is preferable to muscle in the above operation.

J. B. Murphy's Operation (Journ. A. M. A., June 6, 1914.)—This operation will be best comprehended by a study of the accompanying figures. Figure 110 shows the **L**-shaped incision which gives good exposure but avoids injury to the facial nerve. The internal maxillary artery is shown passing inward behind

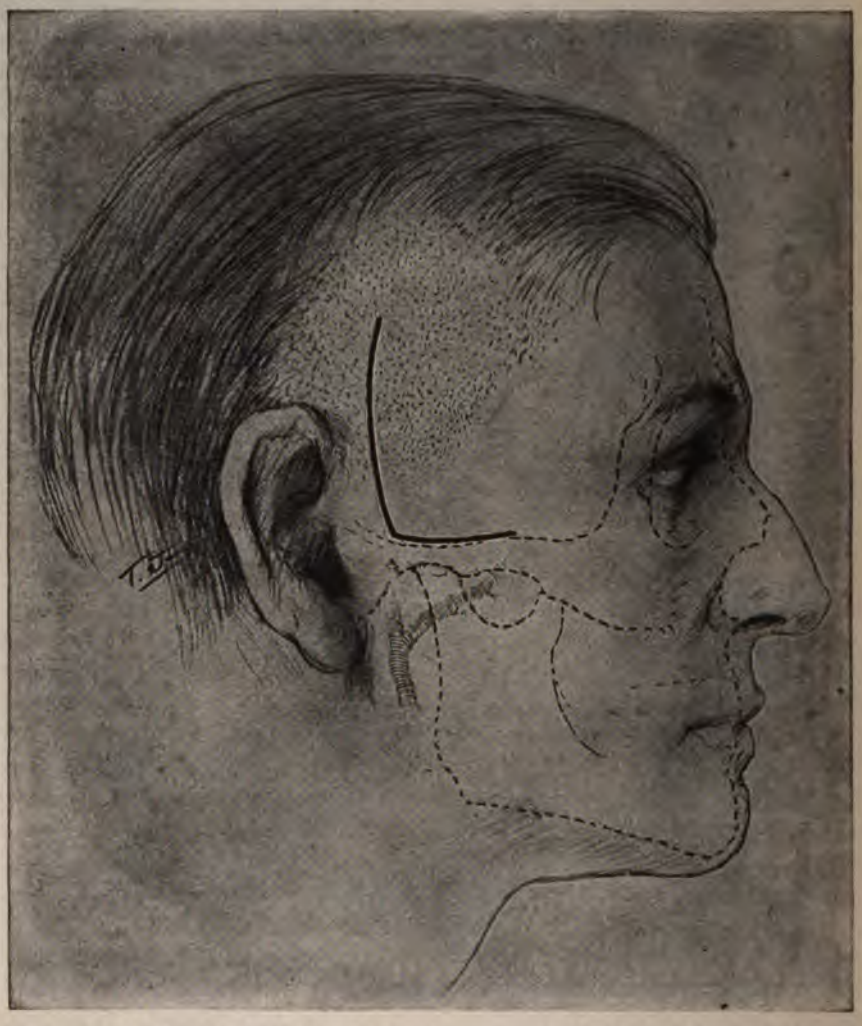


FIG. 110.—**L**-shaped skin incision above the zygoma and in front of the ear, so placed to avoid injury to the facial nerve. Note the relation of the external carotid, the temporal, and internal maxillary arteries to the field of operation. The last-named vessel in passing inward behind the neck of the mandible lies close to the bone and must be carefully protected from injury during the operation, especially at the time when the neck of the mandible is divided. (*Murphy.*)

and close to the neck of the mandible where it is liable to injury unless well protected during the operation. Figure 111 shows the neck of the bone exposed and being divided with a Gigli saw while the internal maxillary artery is protected by means of two curved periosteal elevators.

In Fig. 112 the neck of the bone has been divided, the cut ends of the bone have been separated by traction during which time the protecting curved elevators were kept *in situ*. A flap of fat and fascia is dissected from the temporal region and is turned downwards and inwards between the divided end of the mandible where it is securely anchored by tacking stitches.

FIG. 111.—Dividing the neck of the mandible with the Gigli saw. (In actual operation the saw is not allowed to make so acute an angle as shown in the illustration, because of its great tendency to break when sharply bent.) (*Murphy.*)

The after-treatment consists in keeping the mouth open by means of a wooden block until healing is complete.

How to know which side is anchylosed is important. Murphy's rules for this are:

1. There is flattening of the jaw on the *unaffected* side, most pronounced near the tip of the chin.

2. When the patient attempts to open his mouth, the teeth move from 1/60 to 1/100 inch downwards and deviate a little in the direction of the anchylosed side, because of a slight sliding forwards of the mandibular articulation on the unaffected side as the muscles of the neck are put on tension in the effort made to open the mouth.

FIG. 112.—The pedicled fascia and fat flap is dissected out from the temporal fascia, and the free end of the flap is turned inward between the divided ends of the mandible and sutured securely in place with tacking stitches. (*Murphy.*)

3. A sliding motion on the unaffected side can be felt by the palpating fingers, and the muscular activity on that side is very much greater on attempted opening of the mouth than on the anchylosed side.

4. The muscles on the anchylosed side are more atrophied than those on the unaffected side.

L. W. Arlow* finds that in severe cases of temporo-maxillary anchylosis the pathological changes are by no means limited to the joint, but that osteitis

* Ref. Centralblatt f. Chir., 1903, No. 28.

alters the form, size, and relations of the articular process, the coronoid process, the incisura semilunaris, the zygoma, etc. As a consequence simple division of the articular process is insufficient to give motion, and even when combined with osteotomy of the coronoid it often fails and resection of a part of the full width of the upper portion of the ascending ramus becomes necessary. Facial paralysis is more common as a result of tearing and distraction than of accidental division with knife or chisel. Recurrence is avoided by extensive removal of bone, by the implantation between the fragments of muscle or even of metal plates, and by early passive and active motion. Monod and Vanverts strongly recommend osteotomy of the ascending ramus as being easier than resection of the neck of the bone, as efficient, and not liable to cause injury to the facial nerve. Rochet's method of operating is as follows:

Step 1.—Make an incision bordering the angle of the jaw. About one inch of this incision runs along the lower edge of the horizontal ramus, and about

FIGS. 113 AND 114.—Rochet's operation. (*After Monod and Vanverts.*)

one inch along the posterior edge of the ascending ramus. Through this expose the inferior insertion of the masseter and detach it from below upwards with an elevator. This exposes the outer surface of the bone. In the same way expose the inner surface of the bone by separating the insertion of the internal pterygoid.

Step 2.—With chisel, forceps, or Gigli saw divide the bone along the lines marked in Fig. 113, and remove the bone between the lines of section. The amount of bone should be as great as possible, to permit wide range of motion subsequently.

Step 3.—From the deep surface of the masseter dissect a flap about 1½ inches long, with its pedicle above, consisting of about half the thickness of the muscle. Pass the free end of this flap through the breach in the bone and suture it to the pterygoid (Fig. 114). Should the flap from the masseter be insufficient for the purpose, a subsidiary flap may be taken from the pterygoid.

Step 4.—Close the wound.

CHAPTER X

ODONTOMATA

Odontomata are tumors arising from teeth germs or teeth still in process of growth. Bland-Sutton described seven varieties of this tumor besides the simple dental cyst which develops at the root of a dead tooth. The odontomata are often called dentigerous cysts. The chief importance of these tumors is that they are rarely recognized prior to operation, that they are often wrongly diagnosed as malignant neoplasms and the whole jaw needlessly extirpated. The tumors are non-malignant and are readily removable.

Bland-Sutton writes: "In the case of a tumor of the jaw, the nature of which is doubtful, particularly in a young adult, it is incumbent on the surgeon to satisfy himself before proceeding to excise a portion of the mandible or maxilla that the tumor is not an odontome, for this kind of tumor only requires enucleation." The following operation performed by the author explains the principles of procedure. Incision through muco-periosteum over the prominence of the tumor. With chisel, trephine, or bur cut through the shell of bone (about two lines in thickness). In the posterior part of the tumor a cavity was found containing a perfect premolar tooth with thick mucous membrane attached all round its neck. Tooth removed. The mucosa was attached to a purplish, soft, round, grape-like mass which filled the anterior part of the tumor or bone cavity. This was easily shelled out. The cavity left was the size of a hen egg, was smooth and lined with mucous membrane. The root of the first molar projected into the cavity. Extracted this tooth. Partly closed wound and packed with gauze. The tumor was a typical odontoma. After many weeks the cavity closed completely.

A more rapid closure would have been obtained had the operation been performed as follows:

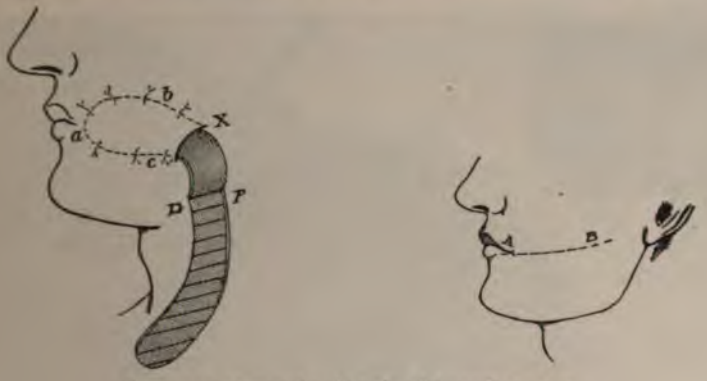
1. Free incision of muco-periosteum over the growth.
2. Reflection of muco-periosteum from over the whole external of the prominent surface of the tumor.
3. Penetration of the bone and removal of the contents of the bone cavity.
4. Removal of all the external wall of the cavity and destruction of the mucous membrane lining the rest of the cavity.
5. Application of the reflected muco-periosteal flaps to the bottom of the cavity. Application of dressings to keep the flaps in position.

CHAPTER XI

EXCISION OF THE CHEEK

If a tumor is located on the buccal surface of the cheek, is not extensive, and does not involve the skin, it may be excised through the mouth by an elliptical incision and the wound closed by sutures. Should the amount of mucous membrane and subjacent tissue removed be great, then, when healing has taken place, there may result fibrous anchylosis of the jaw. To prevent this contraction, one must fill the defect by means of a graft covered with epithelial tissue. Of course, when the anchylosis is the result of an old burn or similar lesion one must excise the scar tissue before implanting the graft.

The Operation.—The tumor or old scar tissue has been excised through the mouth, leaving the defect a, b, c (Fig. 115). On the neck trace the flap D, E, F,



FIGS. 115 AND 116.—Repair of buccal mucosa.

the distal portion of which consists of hairless skin large enough to more than fill the defect. Dissect free the flap outlined. Be sure that the pedicle is wide, thick, and so placed that when turned into position its vessels will not be injuriously twisted. Make an incision (X, Fig. 115) through the cheek into the mouth. Through this incision pass the flap D, E, F, and suture its edges to the margins of the defect a, b, c. After the lapse of ten days divide the pedicle of the flap at X and replace its remnant in its normal position. Close the wound in the cheek. Close the wound in the neck partly by sliding the edges towards each other and partly by skingrafts. [This closure of the wound in the neck may properly be attended to at the original operation.]

When it is impossible to remove the tumor through the mouth, although the skin is not involved one may make the incision A, B (Fig. 116) through the skin alone, reflect the skin-flaps X, Y (Fig. 117), and thus expose the mucous membrane and tumor (T, Fig. 117). Next excise the tumor and fill the resulting defect by the flap (C, E, D, Fig. 118) taken from the neck (or forehead). Replace the flaps X and Y and secure with sutures.

Shelton Horsley (Journ. A. M. A., Jan. 30, 1915), if necessary, provides an epithelial lining for the mouth by means of a flap turned up from the neck or from the tongue. The flap to replace the skin defect is taken from the forehead

FIGS. 117 AND 118.—Repair of buccal mucosa.

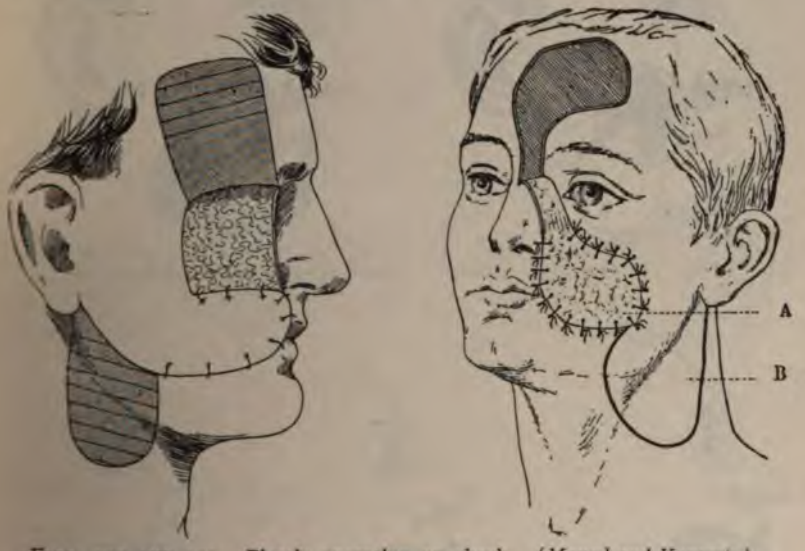
FIG. 119.—(*Horsley, Jour. A. M. A.*)

and instead of being provided with the usual pedicle, transplantation of the anterior temporal artery is practised according to the method published by Monks (Boston Med. and Surg. Journ., 1898) but of which Horsley was ignorant at the time.

The Operation. Anesthetize preferably by the rectal method.

1. Prepare the cheek by trimming away the scar tissue around the defect and by undermining the skin slightly. If it is necessary to replace the mucosa do so by implanting the flap A, B, C, D (Fig. 118).

2. Outline the flap E, F, G. Make the straight incision G, H along the line of the anterior temporal artery. Expose the artery, but do not injure it or grasp it with forceps. Dissect the artery free along with a considerable amount of surrounding tissue so as to preserve the nerve supply of the vessel. Make the incision H, I through the skin alone and prepare a bed for the artery. Complete the mobilization of flap E, F, G and place it in the defect in the cheek. Place



FIGS. 120 AND 121.—Plastic operation on cheek. (*Monod and Vanverts.*)

the artery, which of course runs into the flap E, F, G into the gutter prepared along the line H, I and suture the skin over it. Unite the flap E, F, G by a *few stitches* to the defect. As the drainage of the flap and not its blood supply is liable to be faulty, plenty of opportunity for escape of blood and fluids must be provided, hence few stitches are used. "By the second day the flap is swollen and becomes a dark purple color. If it is too tense, every few hours a sharp knife can be inserted along the edges of the flap to scrape it a little so as to promote bleeding and relieve the tension. After a week the swelling begins to disappear and new capillaries drain away the blood."

Bardenheuer has devised some excellent and ingenious methods of repairing defects in the cheek, defects left after the removal of disease or of scar tissue which gave rise to fibrous anchylosis. Fig. 120 represents a case in which the mucous membrane was replaced by a flap of skin taken from the forehead and provided with an enormously wide and reliable pedicle; the skin was replaced by a flap of skin taken from the neck. After healing was secured the pedicles were divided, the wound trimmed, and all raw surfaces on forehead or neck covered

by skin-grafts. Fig. 121 represents a case in which Bardenheuer brought a skin-flap down from the forehead. The flap was nourished through a narrow flap which contained the supraorbital artery. The defect in the skin was covered by a flap taken from below.

The above operations are described as suggestive types for the repair of defects in the cheek. The operations of Kraske and Israel are also good types (Figs. 122, 123, 124, 125, 126).

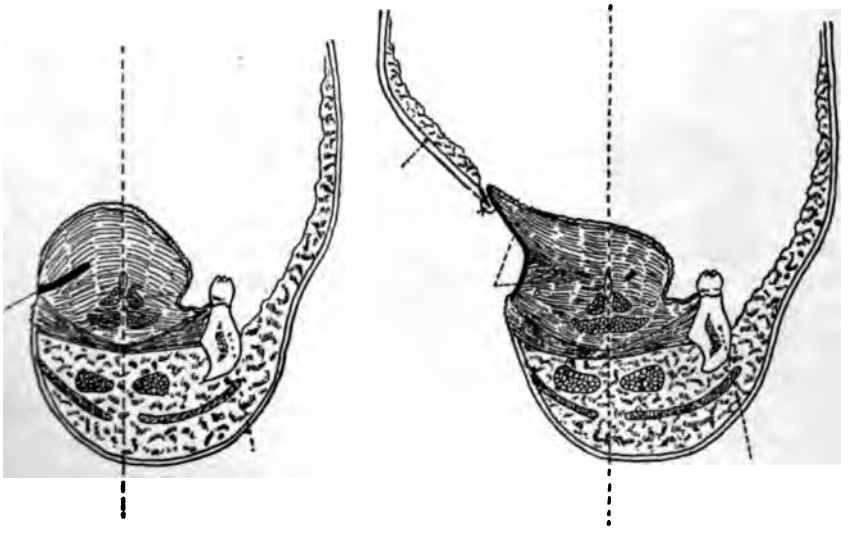
FIGS. 122 AND 123.—Kraske's operation. (*Esmarch and Kowalzig.*)

FIGS. 124, 125, 126.—Israel's operation. (*Esmarch and Kowalzig.*)

W. D. Gillies (Surg. Gyn., & Obst., Feb., 1920) uses a postauricular flap in closing defects of the cheek. When insufficient skin is available from over the mastoid, he includes some skin from the posterior surface of the pinna (Figs. 127, 128, 129, Gillies).

In cases where part of the lower jaw has been removed and where there is a corresponding loss of substance in the cheek Sonnenburg ("Archiv für klin. Chir.," lxxviii, 820) makes an incision along the corresponding side of the tongue (Fig. 130) and so obtains a flap of tissue covered with mucosa. This flap Sonnenburg sutures to the freshened upper edge of the defect in the cheek (Fig. 131.) The oral side of the defect being filled as above, the outer or skin side may now be covered by an appropriate flap from the neck.

S. 127, 128, 129.—Post auricular flap for cheek replacement. (*Gillies, Surg., Gyn. & Obst.*)
Drawn by S. Hernswick.



FIGS. 130, 131.—(*Sonnenburg.*)

Hotchkiss' Operation.—Planned for cases of extensive cancer of the cheek with involvement of the jaw.

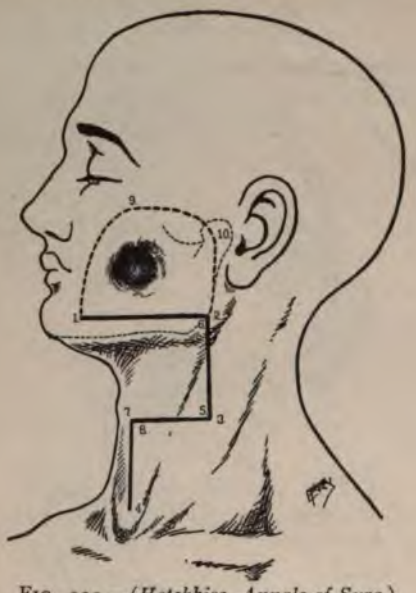


FIG. 132.—(*Hotchkiss, Annals of Surg.*)

FIG. 133.—(*Hotchkiss, Annals of Surg.*)

Step 1.—Make the incision 1, 2, 3, 8, 4 (Fig. 132), through the skin, and reflect the flaps outlined so as to expose the lower border of the inferior maxilla,

FIG. 134.—(*Hotchkiss, Annals of Surg.*)

FIG. 135.—(*Hotchkiss, Annals of Surg.*)

the platysma overlying the submaxillary gland, and the deep structures of the neck.

Step 2.—Free the anterior border of the sternomastoid exposing the chain of glands extending from the submaxillary space to below the level of the cricoid cartilage. From below up remove *en masse* the entire lymphatic chain along the internal jugular vein and beneath the sternomastoid muscle until the bellies of the digastric come into view when the contents of the submaxillary space (both salivary and lymphatic glands) must be dissected free and retracted upwards in one piece (Fig. 133). Doubly ligate and divide the external jugular and facial veins and the external carotid artery.

Step 3.—Expose the outer surface of the lower jaw and prepare it for section. Protect the neck wound with gauze. Make an incision all around the disease on the face and at a safe distance from the disease (1, 2, 10, 9, Fig. 132). This incision penetrates the mouth. Divide the lower jaw with a Gigli saw well in front of the growth. Retract the divided jaw. Divide the floor of the mouth along the groove of the tongue severing the mylohyoid and hyoglossus muscles. Pull the lower jaw and attached structures outwards, and if the disease involves the upper jaw remove the affected bone. Disarticulate and remove the lower jaw along with the diseased tissues (Fig. 134).

Step. 4.—In Hotchkiss' cases "the mucous membrane at the side of the tongue was united to the cut edge of the hard palate, the tongue thus being elevated as a sort of wedge against leakage from the mouth. The edges of the cut mucous membrane in front and behind this were united by suture and the cut edge of the mylohyoid muscle was brought up over this line of union of the mucous membrane, and the skin-flap shown in Fig. 135 was then sutured up to fill in the defect in the cheek. A portion of the incision in the neck was left unsutured and filled with loose gauze packing extending up to the glenoid and temporal fossæ" ("Annals Surg.," Oct., 1908).

CHAPTER XII

LOWER LIP

Epithelioma is the most common cause for removal of the lower lip. The classical method of **removing labial cancers** is by a **V**-shaped incision. This method is applicable to cases in which not more than two-thirds of the width of the lip is involved. The resulting deformity is slight.

The operation is performed as follows: A general or local anesthetic having been administered, an assistant controls the coronary arteries with his fingers and thumbs; the surgeon rapidly cuts through the whole thickness of the lip on each side of the tumor. The two cuts thus made meet at an angle below the tumor, which is now removed. Before the assistant relaxes his control of the coronary vessels the surgeon applies silk or silkworm-gut sutures, either through the whole thickness of the lip or with the exception of the mucous membrane. The sutures are tied and form a sufficient guard against hemorrhage.

When performed as above, the operation is very speedy; so speedy, in fact, that the surgeon may inadvertently make his incision approach a little too close to the tumor. In such operations there is usually nothing to be gained and

much may be lost through great speed. A slight modification in operating leads to greater deliberation and hence greater thoroughness.

The surgeon seizes the tumor and lower lip between the finger and thumb of the left hand, and pulls them forwards and upwards in such a way as to guard against blood entering the mouth. Beginning on the lip margin, at least one-fourth of an inch from the growth, a curved incision is made downwards until the lower limits of the tumor are passed. This incision is made *to* but *not through* the mucous membrane. Bleeding vessels are caught up with hemostats. A similar incision is made on the opposite side, and only after bleeding is stopped is the mucous membrane divided and the growth removed. The wound is closed as in the previous operation. Many surgeons prefer to stitch the mucous membrane with catgut and close the rest of the wound with silk or silkworm-gut. As a matter of routine, the glands through which the lymphatics of the lip drain should be removed even if not enlarged. He would be a bold fool who would say a field had no seed in it because no sprouting verdure was visible. Experience seems to show that it is unnecessary to remove the lymphatics leading from the tumor to the lymph nodes, although theoretically such ought to be removed.

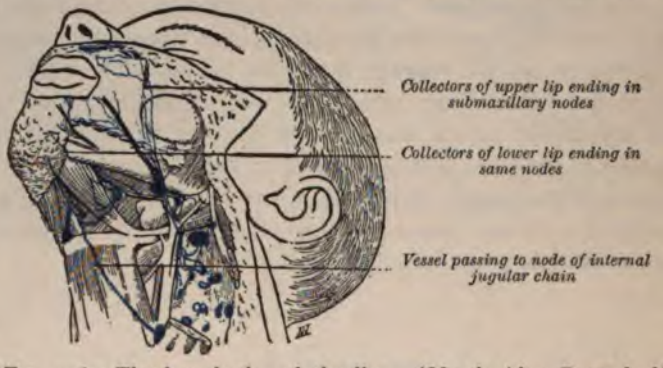

Collectors of upper lip ending in submaxillary nodes
Collectors of lower lip ending in same nodes
Vessel passing to node of internal jugular chain

FIG. 136.—The lymphatics of the lips. (*Morris After Dorendorf.*)

For the sake of obtaining aseptic healing of the wound made in removing the lymph glands this part of the operation may be performed through a separate incision which is closed before the primary disease is attacked. "The capillary plexuses of the skin and mucous membrane are continuous at the free border of the lips. The ducts of the upper lip, of which there are about four on each side, pass to the submaxillary nodes. From the lower lip the trunks from near the angle of the mouth pass to the submaxillary nodes, while those from the centre of the lip pass to the submental nodes. There are from two to four subcutaneous ducts and from two to three submucous ducts on either side. The collecting trunks passing to the submaxillary nodes do not anastomose, and the same is true of the submucous ducts of the lower lip. The subcutaneous ducts, on the other hand, passing to the submental nodes, anastomose freely—an important fact in connection with the extension of cancer of the lower lip." ("Morris' Human Anatomy") Fig. 136.

The submental nodes ought, therefore, to be removed on both sides. Remember that some lymph nodes are closely attached to the submaxillary salivary glands and hence these glands should be excised on the affected side. A

continuation downwards of the incision for the removal of the tumor, the V incision being converted into a Y, and elevation of the skin on each side of the cut give excellent access to the structures requiring removal.

Bloodgood found that excision of the lip and glands, when there was no apparent glandular involvement, resulted in twenty cures among twenty-one cases, while the same operation gave six cures out of twelve cases when metastasis was demonstrably present in the glands. In the six cases in which recurrence took place it was local in one and in the cervical glands in five.

When there is palpable glandular involvement in the neck the operation becomes similar or practically identical with that required in cancer of the tongue. (See Butlin's, Crile's, Maitland's methods described in chapter on the Tongue.)

Very superficial cancers of the lip may be removed by a curved, more or less horizontal incision, the mucous membrane and skin being subsequently sewed together.

A large number of methods for the removal of cancers of the lower lip and for remedying the resulting deformity will be found sketched at the end of this article.

FIGS. 137 AND 138.—Regnier's operation.

Regnier's Operation.—*Step* 1.—The tumor and the *whole* of the lower lip, from one angle of the mouth to the other, are removed by a curved incision. In making this incision it is well to have all bleeding arrested before the mucous membrane is divided and the mouth is penetrated.

Step 2.—The skin and mucous membrane at the edge of the wound are united by sutures (A, Fig. 137).

Step 3.—From the lower edge of the middle of the upper lip measure downwards to the lower edge of the middle of the lower jaw (*e.g.*, call the distance 2¼ inches). From the middle of the wound (A, Fig. 137) measure downwards and mark a point the same distance below A as the mental process is below the edge of the upper lip (in our example, 2¼ inches). Take a point, B, in the middle line, ¾ inch lower than the above (*i.e.*, in our example, 3 inches below A). In the submental region or in the neck, as the case may be, make a curved incision parallel to the wound in the lower lip, and having the point B as its centre. This curved incision must be from 5 to 6 inches in length.

Step 4.—Through the incision at B dissect the skin-flap, A, B, from the subjacent tissues in such a way as to enter the mouth at the line of reflection of the mucous membrane from lip or cheek to gum. In this way a vizor-shaped or double-pedicled flap is formed and can be slid over the lower jaw to re-form the lower lip. The lower edge of this flap is sutured to the periosteum at the lower edge of the jaw (Fig. 138).

Step 5.—A space, C, is left in the submental region through which any enlarged glands may be removed. Ogston maintains that, when the submaxillary gland is enlarged and even slightly adherent to the bone, the bone is probably already involved in the disease and ought to be removed. If this is the case, then it is quite feasible to remove the whole thickness of the bone involved, along with the gland, though the triangular space C. The skin of the neck being very lax and mobile, it is a simple matter to cover at least a large part of the space C with skin. Any uncovered portions may be grafted according to the Thiersch method.

Dressings.—Iodoform gauze should be loosely packed between the newly formed lower lip and the upper part of the external surface of the lower jaw. Externally the usual antiseptic dressings may be applied. The mouth should be frequently washed with a weak solution of permanganate of potash and the dressings changed as required.

Regnier's operation is capable of being modified to meet many conditions, and very great deformities may often be avoided by its means. To the writer it has given great satisfaction.

FIG. 139.—Dowd's operation.

DOWD'S OPERATION

Step 1.—Make the incisions A, B and C, D below and parallel to the lower jaw. Be careful to leave the point X (Fig. 139) attached to the jaw. Expose and remove the fatty and lymphatic tissue of the whole submental and submaxillary region. Remove also the submaxillary salivary glands. If the lymphatics above mentioned are visibly and palpably enlarged, continue the incisions backwards and expose the carotid packet of vessels. Remove the lymphatic glands in this region whether they are palpably enlarged or not.

Step 2.—Remove the disease by means of the incisions A, E, F; C, G, H; A, C. These incisions should be ½ to ¾ inch distant from the disease.

Step 3.—Make the incisions I, E and G, K (each two inches or more in length), down to but not through the buccal mucosa. Divide the mucosa along lines at least ⅓ inch higher, so as to form a flap which may be stitched to the skin and serve as mucous membrane for the new lower lip.

Step 4.—Unite the raw surface A, E to C, G with sutures. The wedge-shaped incisions L and M may aid in the approximation of the new lower lip.

Step 5.—Close the wounds A, B and C, D, after providing for drainage.

Trendelenburg's position ought to be used throughout the operation. In operating on cancer of the lip it is a good rule, where possible, to begin by dissecting out the lymphatics which *may* be diseased. It is, of course, imperative to remove all evidently involved lymphatics, but it is prudent to go further and remove the *apparently* unaffected ones next in order. For example: the submental and submaxillary group of lymphatics appear healthy, or but very slightly diseased: remove them and then excise the primary disease of the lip as well as perhaps the fatty connections between the primary and the secondary foci of disease; again, the submental and submaxillary group are evidently diseased; expose the carotid group of lymphatics, excise them, as well as the submaxillary, etc. One great reason for beginning with the lymphatics is that by so doing the mouth is not penetrated until the difficulties of the operation are practically ended.

FIG. 140.—Sutton's operation. (*Sutton.*)

W. S. Sutton devised an ingenious and successful method of removing tumors involving both upper and lower lips at the angle of the mouth ("Jour. A. M. A.," Aug. 20, 1910). Fig. 140 is self-explanatory. Grant's operation is sufficiently explained by Figs. 141 and 142.

Nelaton and Ombrédanne recommended the two following operations as the methods of choice in cancers of different extent.

Method A.

Step 1.—Excise the cancer by a V-shaped incision. From the apex of the V make one or if necessary two incisions parallel to and a finger's breadth below the border of the lower jaw, outwards to the line of the carotid artery (Fig. 143). Excise the lymphatics extensively.

Step 2.—Close the wound by suture, after providing for drainage (Fig. 144). Closure of the wound produces a very ugly deformity of the upper lip. To correct this make an angled incision E, B, C (Fig. 144) on each side of the mouth. Suture the cut surface E, B to the cut surface B, C. This restores the upper lip. Along the line E, D, C unite the buccal mucosa to the skin. This gives a presentable lower lip (Fig. 145).

FIG. 141.—Grant. (*Bryant's Op. Surg.*)

FIG. 142.—Grant. (*Bryant's Op Surg.*)

Method B.—For very extensive lesions.

Step 1.—Excise the tumor, preferably by incisions which form a triangle with its apex below, so that a cut may run down from the apex to expose the lymphatics beneath the jaw.

Step 2.—On each side proceed as follows: From the angle of the mouth make an incision (A, B, Fig. 146) directed towards the inferior border of the tragus.

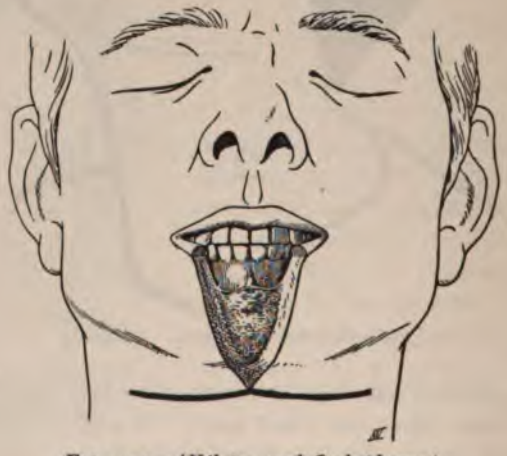


FIG. 143.—(*Nélaton and Ombrédanne.*)

Divide *the skin only*. Open the mouth. Mucous membrane exists under the anterior portion of the cut A, B. Divide the mucous membrane parallel to but about ⅛ inch above the skin incision. (By suturing the mucosa to the skin a red border is provided for the new lower lip.) Make the skin incision B, C parallel to the wound made in the excision of the disease. The lower end of the cut B, C, is about a finger's breadth below the lower border of the lower jaw. In making the cuts A, B and B, C do *not* injure the parotid. Reflect the flap out-

lined by the cuts AB, BC; to do this it is necessary to divide the mucosa vertically along the the anterior edge of the masseter. Be careful *not* to divide the facial artery where it crosses the border of the lower jaw, but separate it, with the flap, from the jaw.

Step 3.—Clear away the lymphatics and the submaxillary glands but carefully preserve the facial artery; if necessary, the facial vein may be sacrificed.

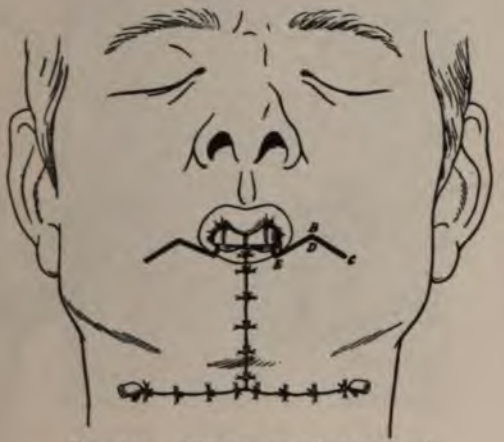


FIG. 144.—(*Nélaton and Ombrédanne.*)

Step 4.—Suture the mucosa to the skin on the upper edge of the flap (see Step 2) so as to form a red border for the new lower lip (X, A, Figs. 147 and 148).

Step 5.—Suture the lower edge of the mucous membrane of the new lip to the cut edge of the mucous membrane on the lower jaw (L, L, Figs. 147 and 148).

FIG. 145.—(*Nélaton and Ombrédanne.*)

This forms the line of reflection of the mucous membrane between the lip and the jaw. The rest of the operation is sufficiently explained by Figs. 148 and 149.

Clark Stewart's operation ("Jour. A. M. A.," Jan. 15, 1910) gives good exposure of the submaxillary lymph nodes and permits of the excision of the lymph nodes, submaxillary glands and the tumor in one piece.

"The first incision extends just below the jaw from one angle to the other and cuts the skin and platysma muscle, which are then carefully dissected down

FIG. 146.—(*Nélaton and Ombrédanne.*)

FIG. 147.—(*Nélaton and Ombrédanne.*)

FIG. 148.—(*Nélaton and Ombrédanne.*)

FIG. 149.—(*Nélaton and Ombrédanne.*)

to the level of the thyroid cartilage (Fig. 150). All tissues down to the muscles are then sectioned at this line and a clean dissection is made elevating all loose connective tissue, lymph nodes, etc., in a flap which extends laterally to the great

n each side. The facial artery and vein are ligated and the submaxil-
ıds are loosened and raised in the flap on each side. Incisions are now
each side of the epithelioma far enough away to include all infiltrated
ıd these are carried down to the cross-section already made.

FIG. 150.—(*Stewart, Jour. A. M. A.*)

lateral flaps are now dissected free from the jaw, keeping close to the
the lower part to avoid lymphatics, and finally the intervening central
loosened from the jaw and removed. This contains the tumor and a
ed mass of skin and the deeper tissues attached to the lympth nodes of

FIG. 151.—(*Stewart, Jour. A. M. A.*)

, and the submaxillary gland by a loose flap of tissue which contains the
ng lymphatics.
submaxillary glands should always be removed, not because they are
in early cases, but because there is regularly a lymph node attached
which is one of the first to be involved. In cases in which not over
ıths of an inch of the vermilion edge of the lip has been removed,

simple suture of the wound with drainage of the submaxillary fossæ completes the operation. In cases in which the mouth must be extended on account of more extensive removal of the lower lip, the procedure shown in the drawings is convenient.

The mouth is broadened by a straight incision outwards at either or both angles, and this incision is carried down to but not through the mucous membrane; the latter is then cut one-half inch higher and stitched to the raw surface of the new lip (Fig. 151). To avoid puckering of the upper lip a triangle of the skin is taken out of the cheek to allow of the smooth drawing together of the lower lip (Fig. 152). The new chin should be sutured to the soft tissues over the lower jaw to exclude mouth fluids from the neck wound."

FIG. 152.—(*Stewart, Jour. A. M. A.*)

Mayo's Operation.—*Step* 1.—Make a collar incision through the skin and platysma ¾ inch below the mandible from one sternomastoid to the other. Reflect the skin and platysma down to the hyoid bone and up to the mandible. Remove all fascia and fat as well as the submaxillary salivary glands from the submental and submaxillary triangles on both sides. Ligate the facial arteries and veins but preserve the hypoglossal and lingual nerves.

As soon as the glands have been removed from one side have them examined microscopically while those on the other side are being removed. If they are innocent of cancer complete the operation by suturing the platysma and then the skin after providing for drainage and proceed to the excision of the lip. If the glands are cancerous further dissection is essential as described in Step 2. If they are not cancerous proceed to Step 3.

Step 2.—Make an incision along the sternomastoid muscle, reflect the skin and platysma sufficiently to expose the whole region of the sternomastoid on that side of the neck from which cancerous glands were obtained. Divide the sternomastoid at its lower end and from below up make a block dissection of all the glands and gland-bearing fascia of the entire neck, including the anterior and

posterior deep jugular glands up to the mastoid process. Removal of the sterno-mastoid is necessary to a complete dissection. Be very careful to clean out the glands in the posterior part of the submaxillary triangle.

FIG. 153.—(*Beckman.*)

Provide for drainage. Close the wound. Delay operation upon the lip until danger from infection of the great cervical wound is past.

RESULTS AFTER OPERATION FOR CANCER OF THE LOWER LIP (BECKMAN, MAYO CLINIC, 1913)

Group	No. of cases	No. operated	Traced	Not traced	Cured	Not cured	Inoperable	Per cent. cured
I. Clinical diagnosis only	25	2	6	19	2	23	17	.....
II. Primary radical operation	126	126	99	27	83	16	.....	83.8
Glands involved	18	18	18	.....	9	9	.....	50.0
III. Late radical operation	25	25	20	5	14	6	.....	70.0
Glands involved	12	12	12	0	4	8	.....	33.3
IV. Glands removed one side or incomplete	5	5	5	0	2	3	.....	40.0
V. Local excision only	18	18	15	3	11	6	.....	73.3

Step 3.—Figure 153 sufficiently elucidates the removal of the disease in the lip.

CHIN AND JAW

Occasionally an operable cancer involves the soft parts of the chin, the floor of the mouth, and a portion of the lower jaw. The following method has proved useful in such cases:

FIG. 154.

FIG. 155.

Step 1.—A stout thread is passed through the tongue so as to have command over that organ.

Step 2.—An incision is made through the skin around the tumor. From the lowest part of this a cut is made downwards through the skin of the submental region and neck to a point A (Fig. 154). The cut A, B, is made through the

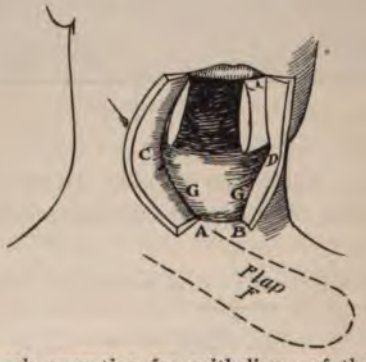


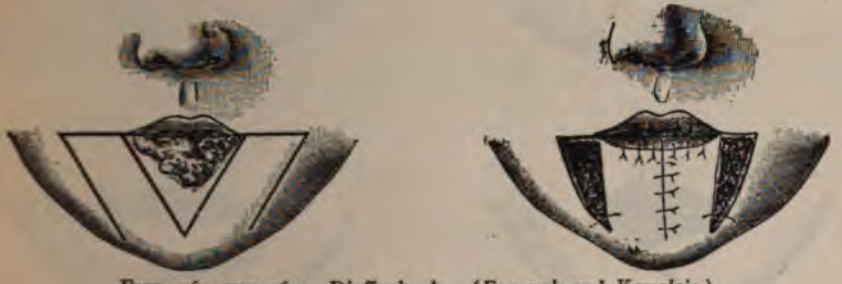
FIG. 156.—Author's operation for epithelioma of the chin and jaw.

skin. The incision around the tumor is deepened until the bone is reached, but the mouth should not be penetrated until all bleeding vessels have been caught. By proceeding thus, time is not wasted by the necessity of swabbing blood from the pharynx.

Step 3.—The flaps A, C and B, D (Fig. 155) are reflected, giving easy access to the bone. The horizontal ramus of the lower jaw is divided by a chain or finger saw on each side of the tumor.

FIGS. 157 AND 158.—Bruns. (*Esmarch and Kowalzig.*)

FIGS. 159 AND 160.—Estlander. (*Esmarch and Kowalzig.*)



FIGS. 161 AND 162.—Dieffenbach. (*Esmarch and Kowalzig.*)

FIGS. 163 AND 164.—(*a*) Jaesche; (*b*) Trendelenburg. (*Esmarch and Kowalzig.*)

Step 4.—Posteriorly to the tumor and from below upwards the floor of the mouth is divided in such a manner that all bleeding is *invited* and arrested before the scissors or knife enters the mouth.

Step 5.—It is now easy to remove all the diseased structures—chin, jaw, floor of mouth, glands, etc., *en masse.*

Step 6.—If possible, the edges of the oral mucous membrane should be united by silk or catgut sutures. The skin-wound is closed by silkworm-gut.

FIGS. 165 AND 166.—Burow. (*Esmarch and Kowalzig.*)

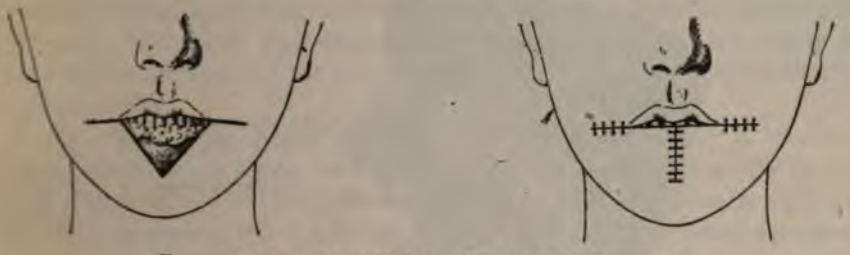
FIGS. 167 AND 168.—Blasius. (*Esmarch and Kowalzig.*)

FIGS. 169 AND 170.—Langenbeck. (*Esmarch and Kowalzig.*)

Dressings.—The floor of the mouth should be lightly packed with iodoform gauze. The external wound should be covered by an *antiseptic* dressing. Frequent washing of the mouth with a weak permanganate of potash solution is necessary. Food ought to be given through the stomach-tube, though the patient may drink water if he so desires. It is important in all such cases to encourage the patient to leave his bed as early as possible. This helps to avoid the great danger in such cases, viz., septic pneumonia.

Should the first part of Step 6 of the previous operation be impossible owing to lack of mucous membrane, then an attempt may be made to supply the defect as follows: In the neck (where hairs are absent) trace out a flap of skin (F, Fig. 156) in such a position and of such a size that, allowing for shrinkage it

can be made to fit into the floor of the mouth. Turn the flap F up and stitch its *distal* or free end to the *anterior* portion of the mucous membrane wound. The most posterior stitches unite the mucous membrane of the side of the mouth near the root of the tongue to the raw edges of the flap near its pedicle. This gives an epithelial lining to the floor of the mouth. The flaps A, C and B, D (Fig. 156) are now sutured over flap F; both flaps, A, C and B, D, having been



FIGS. 171 AND 172.—Trelat. (*Monod and Vanverts.*)

FIGS. 173 AND 174.—Serre. (*Monod and Vanverts.*)

split (G) to permit the passage of flap F into the mouth. The wound left by the transplantation of flap F is to be closed by sutures or by Thiersch's skin-grafts. Of course, a secondary operation will be necessary to close the hole G and to divide the pedicle of flap F.

Several well-known methods of excising the lower lip and repairing the defect are illustrated by Figs. 157 to 174.

CHAPTER XIII

UPPER LIP

Excision of the upper lip is usually demanded because of malignant disease, but scars resulting from infective lesions, burns, etc., may require excision and repair.

As in other regions, when operating for malignant disease, it is necessary to know the anatomy of the lymphatics as the lymph nodes into which the diseased area drains must be thoroughly removed. The lymphatics of the upper lip pass into the submaxillary lymph nodes but on their way they may pass through certain facial nodes, viz., (a) the infra-maxillary and supra-maxillary nodes resting on the lower jaw near where it is crossed by the facial artery, (b) the anterior and posterior buccinator nodes, superficial to the buccinator fascial

lying on a line connecting the lower margin of the ear and the angle of the mouth.

The posterior nodes lie near where the parotid duct perforates the buccinator muscle, the anterior nodes lie between the facial artery and vein (Fig. 175). In excising malignant neoplasms from the upper lip remember that the mid-

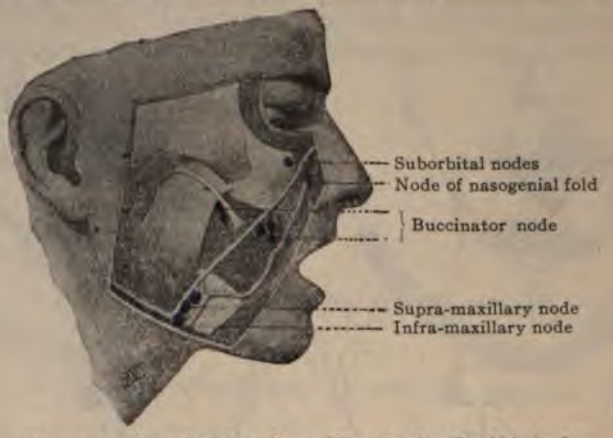


FIG. 175.—The facial nodes. (*Morris after Buchbinder.*)

groove of the lip is of the same developmental origin as the columella nasi and that disease may early pass from the former to the latter structure. Removal of the diseased upper lip scarcely requires description; repair of the resulting defect may be difficult.

Principles of Repair.—Union of the edges of the defect must be accomplished without tension being exerted on the sutures; without too great puckering of

FIG. 176.

the lower lip; without disfiguring twisting of the angles of the mouth which might give the expression of a fixed sneer; without displacement of the *alæ nasi* sufficient to interfere with the patency of the nostrils.

Method 1.—The neoplasm is at or near the middle line and is not of great size. *Step* 1.—Make the vertical incision AB and A′B′, Fig. 176, on each side of and three-fourths of an inch distant from the disease. Cut through the whole

thickness of the lip. Continue the incisions upwards curving around the alæ of the nose to the points D and D′. By a transverse cut join the points B and B′ thus separating the alæ of the nose from the cheeks and upper lip and dividing the columella nasi. Remove the diseased segment of the lip. Attend to hemostasis.

Step 2.—Everting the remnant of the lip on one side make an incision through the mucosa to the bone along the reflection of the mucosa from the cheek to the upper jaw. With blunt and sharp dissection separate the soft parts from the bone to such an extent that the whole cheek is fully mobilized. Do the same on the opposite side.

Step 3.—Try to approximate the cut surfaces AB and A′B′. If tension is too great, mobilize the cheek more thoroughly. This mobilization may be very extensive and without danger *if* the surgeon "hugs the bone" in carrying it out. When AB is approximated to A′B′ the cuts BD and B′D′ often become puckered and press objectionally against the *alæ nasi* causing obstruction of the nostrils. To avoid this excise the segments of cheek BED and B′E′D′. Suture AB to A′B′ as in hare-lip. Suture the divided columella to the new upper lip. The upper lip may be repaired in this fashion after three-fourths of it has been excised.

If there is much puckering of the lower lip resulting from the operation it may be corrected by an operation the same as that described for the lower lip (p. 120) the lines of incision being of course reversed.

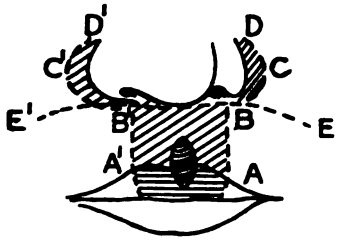


FIG. 177.

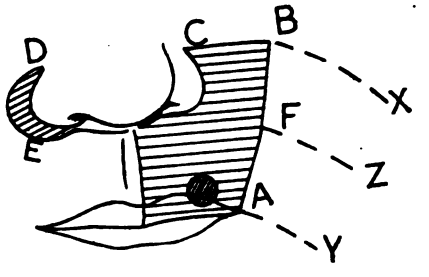


FIG. 178.

During the operation the facial lymph nodes may be looked for and removed. On completion of the operation remove the submaxillary nodes through a special incision and if necessary remove other suspected cervical nodes.

Method 2.—Lenthal Cheatle's operation. At a distance of at least three quarters of an inch from the tumor make the vertical incision AB, Fig. 177, through the whole thickness of the lip. Continue the incision along the curved line BCD a short distance lateral to the groove separating the *ala nasi* from the cheek. On the opposite side of the growth make the corresponding incision A′B′C′D′. From the point D make an incision along the *ala nasi* groove, skirting the ala and cutting it off from the lip. Do the same on the opposite side. Divide the columella nasi, sacrificing a part of its base. Remove the area of lip and cheek between the incisions ABCD and A′B′C′D′.

To facilitate approximation of the edges of the wound make the two curved incisions BE and B′E′ about 1½ inches long, through the whole thickness of the cheek. These incisions must *not* injure Stenson's duct which is easily seen in

the mouth and avoided. Through the incisions BE and B′E′ look for the buccinator lymph nodes and remove them if they are present. Suture the wound AB to the wound A′B′. Close the curved incisions beside the *alæ nasi*. Suture the columella nasi to the new upper lip.

Method 3.—The disease is not extensive and is situated in the lateral portion of the lip.

Lenthal Cheatle's Operation.—Three-fourths of an inch internal to the disease divide the lip vertically from its margin up into the nostril or to the columella. From the point A, Fig. 178, three-fourths of an inch external to the disease, at or near the angle of the mouth make an incision AB upwards and outwards towards the external canthus of the eye. The upper end of the incision is on the level of the upper end of the *ala nasi*. Make the incision BC down to the bone. From the point C make an incision following the curve of the *ala nasi* to meet the original vertical incision.

Remove the disease along with the tissues in the shaded area in Fig. 178. Repair must be effected by bringing the opposite half of the upper lip over to meet the edge of the wound AF. To do this without undue tension divide the connections between the remnants of the lip and the jaw; cutting against the bone, widely separate the tissues of the cheek from the bone on the healthy side By incision separate the *ala nasi* of the healthy side from the cheek and from the lip. To avoid puckering of tissues excise the crescent of tissue DE, Fig. 178. Divide the columella at its junction with the upper lip. If tension has been sufficiently relieved the remnant of lip can now be brought near the wound AF. To prevent puckering of the angle of the mouth and to relieve tension make the incision AY outwards and downwards from the angle of the mouth, through the whole thickness of the cheek. From the point F on the level of the nostril, make the incision FZ through the whole thickness of the lip. From the point B make the incision BX down to the bone. Reflect the flap ZFBX and excise the buccinator lymph nodes. Suture the wound AF to the remnant of the upper lip. Suture the wound BF to the ala nasi. Suture the columella to an appropriate point on the new upper lip. Excise the submaxillary lymph nodes.

Method 4.—The disease is extensive. Excise the whole upper lip.

Nélaton-Ombrédanne Operation.—Trace the flap ABCDE on each side of the defect (Fig. 179). "The side AB is formed by the border of the defect and in length is a little more than one-half the transverse diameter of the defect. Perpendicular to this side, we trace the line BC slightly concave upwards and shorter than the vertical diameter of the defect. The result of this will be that the flap when transposed will be a little too long and not quite deep enough but the elasticity of the skin will permit a sufficient gain in the depth at the expense of the length of the flap when sutures are being inserted. Mark the point E, 2 to 2½ cm. (¾ to 1 inch) horizontally outwards from the angle of the mouth; between and equidistant from the points C and E choose the point D which must be about 1 cm. external to an imaginary line uniting C and E. Join CD by a line slightly concave externally. Join DE by a straight line. This completes the tracing of the flap.

The cuts AB and DE penetrate into the mouth. The cuts BCD penetrate to the bone. Divide the reflection of the mucous membrane between the jaw

and cheek; and dissect the flap BCD from the bone. The flap ABCD is covered with mucosa except at its point. Along the edge AB suture the mucosa to the skin so as to form a red edge for the new lip, if necessary excising a few millimeters of skin to make the mucosa more prominent. Suture the edge BC to its homologue on the opposite side (Fig. 180): the incision BC being slightly concave

FIG. 179.—(*Nélaton and Ombrédanne.*)

FIG. 180.—(*Nélaton and Ombrédanne*).

its suture makes a little prominence on the free border of the new lip. When inserting the sutures begin with those in the mucosa. The curve of the incision CD fits it well for its new position under the nose. In closing the resultant defect DC'D'E do not try to unite the two sides of the rectangle which are closest to each other; this would deform the new lip giving it a horrible fixed sneer. Suture the point δ to the point β so as to form a sort of star into the branches of which a few sutures may be inserted.

ANGIOMATA OF THE FACE

Angiomata of the face when small may require no treatment; when larger they may be treated by the application of "dioxide" snow or by excision; when superficial and extensive their owner may treat them with resignation but when pulsatile or very large, deforming and threatening to life, more active treatment may be necessary. Excision is often too dangerous and disfiguring. Ligation is inefficient. Injection of coagulating materials is commonly insufficient and involves grave dangers from embolism. Morestin (Rev. de Chir., Feb., 1914) has injected solutions of formalin to kill or "fix" the diseased tissues but precedes the injections by ligating the principal afferent and efferent vessels. The temporary cessation or lessening of the local circulation lessens the dangers from embolism and increases the efficiency of the injections. Morestin's formalin solution consists of equal parts of formalin, 90 per cent. alcohol and glycerine, of which any amount from 1 c.c. to 12 c.c. or more may be injected according to circumstances. The injections may require to be repeated several times but no new injection should be made until the reaction from the previous one has subsided.

The Operation.—A general anesthetic is necessary in the first operation; if the injections require to be repeated the tissues are so altered that no anesthetic is required in the later operations.

Step 1.—*Ligation of the Vessels.*—According to the case ligation is practised on one or both sides. Bilateral ligation is proper when the lesion is very extensive, passes over the middle line and is pulsatile.

Make an oblique transverse incision whose center is on the anterior margin of the sternomastoid muscle one finger's breadth below the angle of the jaw. Retract the sternomastoid. Penetrate cautiously between the facial and external jugular veins. According to the site and extent of the lesion tie the facial vein, or the facial and external jugular or even the internal jugular (this last of course only on one side). It is best to place the ligatures around the veins but not to tie them until after the arteries have been tied.

Recognize the external carotid artery opposite the tip of the greater horn of the hyoid. Pass a ligature round the artery; expose its principal branches (facial superior thyroid, lingual) and tie them separately. Unless these branches are tied, anastomosis is so quickly established as to render useless the ligation of the main artery. Close the wound.

Step 2.—Charge a syringe with the fixative solution and arm it with a long, fine needle. Introduce the needle through the skin at the periphery and push it through the tumor mass. Slowly withdraw the needle at the same time expressing the contained solution drop by drop. Do not inject any of the solution close to the skin or mucous membrane, otherwise sloughing will occur. Repeat the injection until the whole of the angioma has been injected (in some very large tumors it is better to inject one segment of the tumor at a time).

Morestin writes: "In pulsatile angiomas the dose of solution must be large even although it may cause massive sloughing; the dangers from the disease justify the risk. When the integument is diseased it is difficult to obtain a cure without greater or less destruction of the skin but in these cases it is preferable not to attack the superficial parts of the disease at the first sitting, they may be treated later."

"A few hours after operation swelling begins and increases to very large proportions during three or four days, but there is comparatively little discoloration. Pain as a rule is slight and ephemeral. General symptoms are usually absent. After four or five days the swelling begins to diminish. The tumor itself persists for a time as a hard mass but little by little this softens and the tissues may become quite pliable."

CHAPTER XIV

HARE-LIP

Time to Operate.—On the whole, it may be taken that it is better to operate after the patient has passed the first two months of life than at an earlier period, although many surgeons operate by choice within a week or two of birth.

Position of Patient and Surgeon.—Chloroform having been administered, the patient should be put in Rose's position. The shoulders being supported on a pillow, the head is allowed to hang backwards over the end of the table. In this posture the anterior nares are at a *lower* level than the entrance to the

trachea, and thus it is easier for blood which has gathered in the nose or pharynx to escape through the nares than to be aspirated into the lungs. For the same reason much trouble caused by the collecting of blood in the pharynx is obviated. Trendelenburg's position has the same advantages. Ether may be administered and blood and secretions removed by means of proper apparatus such as is used in operations on the tonsils. The surgeon sits with his back to the window opposite the patient's head. The first assistant stands beside the patient's left shoulder.

Fundamental Principles of Hare-lip Operations.—1. Tension must be relieved, so that the function of the sutures is practically merely to hint to the edges of the cleft that they must stay in apposition.

2. The edges of the cleft must be freshened so that union can take place.

3. This freshening must be done in such a way that the edge of the upper lip opposite the line of suture is made to project below the normal level of the lip. The object of this is to avoid the occurrence of a notch on the lip after the wound has shrunk when healing is complete.

4. The freshened edges of the cleft must be brought together and kept together.

To these fundamental principles James E. Thompson adds the following:

5. The red line of the lip must extend in a clean, unbroken curve from one side of the newly formed lip to the other.

6. The depth of the mucous membrane must be equal on each side of the line of suture.

7. The newly formed lip must not be too short, but must be lengthened so that it will more than cover the gums.

8. The nostril must be reproduced so as to have exactly the same dimensions as the sound nostril, and must consist of tissue of the same texture as the normal nostril.

9. There must be no flattening of the nose or ala nasi on the affected side.

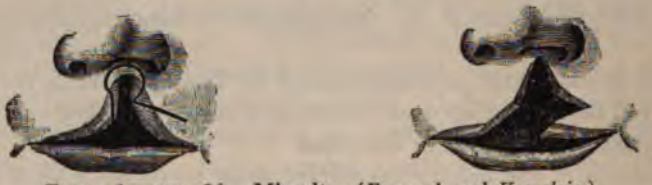
SINGLE HARE-LIP

Incomplete Hare-lip.—The cleft in the lip does not extend into the nostril; it is often a mere notch. It may be unnecessary to relieve tension, though when the cleft is at all extensive or wide this is necessary and must be done thoroughly. Malgaigne's operation gives good results, but Nélaton's is the one usually recommended. These operations and a few others will be easily understood by a glance at Figs. 181 to 186.

In incomplete hare-lip, when the ala of the nose is pulled to the side and the nostril much widened, C. H. Mayo relieves tension very thoroughly, separating the ala of the nose from its deep connections; then he makes his denudation at the floor of the nostril (Fig. 187, A, B), and by pulling the lip downwards and introducing sutures, converts the horizontal wound A, B into a vertical one (Fig. 188). The result is obliteration of the notch in the lip and correction of the deformed position of the ala of the nose.

FIGS. 181 AND 182.—Malgaigne. (*Esmarch and Kowalzig.*)

FIGS. 183 AND 184.—Nélaton. (*Esmarch and Kowalzig.*)



FIGS. 185 AND 186.—Mirault. (*Esmarch and Kowalzig.*)

FIGS. 187 AND 188.—C. H. Mayo's operation.

FIG. 189.—Relief of tension.

FIG. 190.
The dotted area represents the extent of dissection that is commonly required for the relief of tension.

Complete Single Hare-lip.—*Relief of Tension.*—This is one of the most im-tant steps of all hare-lip operations. Failure to relieve tension completely he most common cause of bad results.

The upper lip is everted and pulled upwards and outwards by the finger thumb of the left hand (Fig. 189). The mucous membrane is incised at its ction from gum to lip, and divided from the premolar region on one side to premolar region on the other side, if necessary. Through this incision, a knife or scissors, one separates the soft parts from the bones (keeping the rument close to the bone). Particular attention must be paid to the sepa-on of the ala of the nose from the bone (Fig. 190).

To what extent must the soft parts be separated from the bone? The answer he foregoing question is, until the edges of the cleft in the lip, when placed ether, show a tendency to lie in apposition, so that the sutures when intro-ed may be tied without giving rise to tension.

Freshening of the Edges of the Cleft.—The methods of freshening the edges of cleft are legion.

FIGS. 191 AND 192.—Collis' operation.

The Collis Operation for Single Hare-lip.—Tension having been relieved, ke the incision A, B (Fig. 191) along the line of junction between mucous mbrane and skin. Dissect the mucous membrane, corresponding to that ision, from the subjacent tissues until the whole edge A, B of the cleft is raw. e mucous membrane may be entirely removed or may be left as a flap (F, g. 192) having its pedicle posteriorly. If the flap is left attached it forms, ien the operation is completed, a sort of valve vering the posterior surface of the wound. In ew weeks no trace of it will be found.

On the external edge of the cleft make the ision C, E, D (Fig. 191) through the whole ickness of the lip. At the point E divide the p thus formed by a horizontal incision. This sults in the formation of two flaps, C e' and D (Figs. 191 and 192). Stitch the raw surface of e flap C e' to the highest possible part of the w surface A, B. This brings the ala of the nose o good position and provides an epithelial covered floor to the anterior ss. Turn the flap D e (Fig. 193) downwards and stitch it to the lowest sible part of the raw surface A, B. Stitch the point E (Fig. 193) to the le of the raw surface A, B. When all the sutures are in place and tied, the l line will appear as represented in Fig. 193.

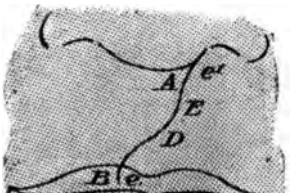


FIG. 193.—Collis' operation.

This operation wastes no valuable tissue and gives a particularly long upper lip. Fig. 194 to 202 suffice to illustrate some other well-known methods of operating.

Sutures.—One or two deep sutures involving almost the whole thickness of the lip must be inserted. The best material for these is silkworm-gut. Hare-lip pins have been discarded, as they cause too much scarring. Usually the deep sutures are inserted through the skin and give rise to considerable scarring at their points of entrance and emergence; a better plan is to introduce the *deep* sutures from the mucous surface and *not* to involve the skin in their bite;

FIGS. 194, 195 AND 196.—Giraldes. (*Esmarch and Kowalzig.*)

FIGS. 197, 198 AND 199.—König. (*Esmarch and Kowalzig.*)

FIGS. 200, 201 AND 202.—König. (*Esmarch and Kowalzig.*)

when this is done, these stitches must not be removed until healing is complete, when they will generally be found to have cut their own way out. If the surgeon endeavors to remove such sutures at the end of a week, he requires to evert the lip, and thus jeopardizes the line of union. Several superficial cutaneous sutures must be introduced; the best material for these is horse-hair. Horse-hair sutures, because of their elasticity, leave less scar than any others. All cutaneous sutures (superficial and deep) may be removed by the seventh day.

DOUBLE UNCOMPLICATED HARE-LIP

When the deformity is not complicated by the central portion of the lip being carried forwards towards the tip of the nose by the intermaxillary bone, the following operation will generally be found satisfactory.

Make the incisions A, B, C and D, E, F (Fig. 203) through the whole thickness of the lip. At the points B and E divide each of the flaps thus formed into two. The edges of the central portion of the lip (Figs. 204, 205, 206) are now to be pared. On each side there are now two flaps, an upper and a lower.

FIG. 203.

FIG. 204.

The raw surfaces of the upper flaps are to be sutured to the lateral raw surfaces of G as high up as possible. Corresponding to the lower edge of G, the horizontal incisions H and I (Figs. 204 and 205) must be made through the whole thickness of the lip on each side. This procedure permits the easy approxima-

FIG. 205.

FIG. 206.

tion of the edges of the cleft below the level of the central part (G). The two lower flaps when their raw surfaces are sutured together form a prominence on the edge of the new upper lip. The appearance of the wound when the operation is completed is represented in Fig. 206. Other methods of operating are sufficiently illustrated by Figs. 207 to 215.

FIGS. 207, 208 AND 209.—Maas. (*Esmarch and Kowalzig.*)

James E. Thompson ("Surg., Gyn., Obst.," May, 1912) good-naturedly laughs at many of the operations for hare-lip figured in this and other books giving diagrams representing what the true results must be, alongside the time-honored figures showing the results as imagined by the inventors of the opera-

tions. To insure accuracy in making his incisions, Thompson uses sharp-pointed compasses which can be fixed by a screw and with them makes all necessary measurements and marks.

Thompson's Methods.—I. Single complete hare-lip without much divergence of the sides of the cleft. At A and A′, Fig. 216, 1, a projection or shoulder shows the junction of the cleft and the nasal margin. With compass measure the distance from Y (midway between A and A′) to Z placed on an imaginary line KL which represents the natural curve of the upper lip. Fix the compasses so that their points will remain this distance (YZ) apart. Place one point of the compasses at A and the other at B on the *skin* of the lip close to the red line of the mucous membrane. Mark the point B, Fig. 216, 2, by pricking the skin. In the same fashion find and mark the point B′. The line AB equals

FIGS. 210, 211 AND 212.—Hagedorn. (*Esmarch and Kowalzig.*)

FIGS. 213, 214 AND 215.—Simon. (*Esmarch and Kowalzig.*)

in length the line A′B′. Readjust the compasses and take the measurement BC, the point C being on the free margin of the lip. The angle ABC is usually about 60° and must always be less than 90° if a projecting prolabium is to result from the completed operation. Mark the point C by pricking the mucosa. In the same fashion find and mark the point C′. The line BC equals in length the line B′C′. Pass a retaining stitch of horse-hair "through each side of the mucous membrane of the lip close to, but below, C and C′." Suture A to A′, B to B′, C to C′, Fig. 216, 3.

II. The sides of the cleft are unsymmetrical. Fig. 216, 4, shows how the same operation gives the same results provided that the cheeks have been well mobilized as advised on p. 137.

III. Double hare-lip. In Figs. 216, 5, and 216, 6, "the shoulders marking the margins of the nostrils are shown at A and E, and at A′ and E′. The triangle E′DE shows the line of incision by which the central piece of skin covering the intermaxillary bone is pared. E and E′ are placed on the inner margins of the nostrils. The sides DE and DE′ are usually equal in length to one another and their length varies according to the depth of the central piece of skin. It

ust never be greater than AB and is usually much less. The points A, B d C and A′, B′ and C′ are chosen as described previously in the operation single hare-lip. Fig. 216, 6, shows the final appearance of the lip when the ps have been cut and the parts approximated. The point A is in contact

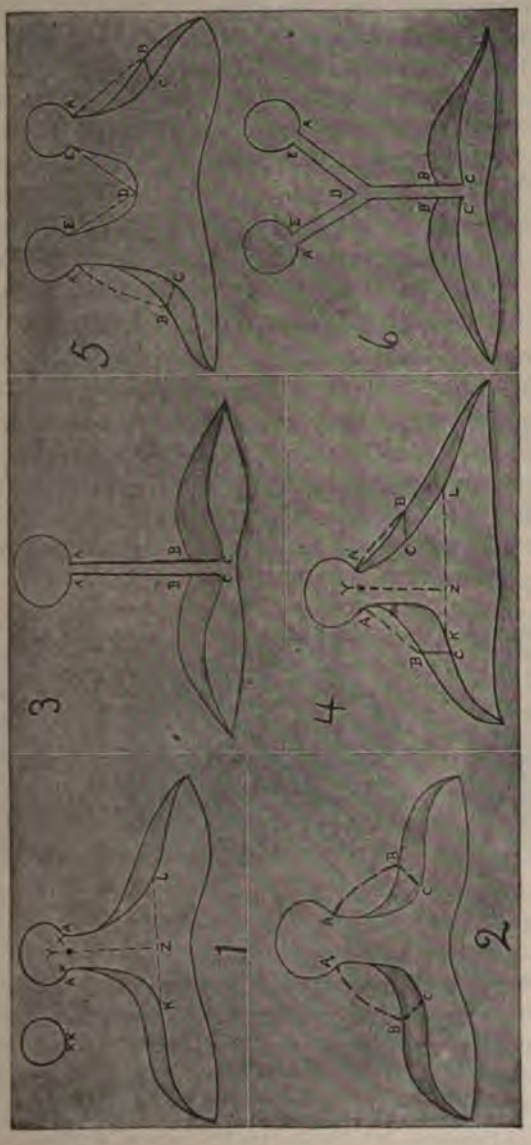


FIG. 216.—(*Thompson.*)

ith E, A′ and E′; the apex D of the triangle E′DE lies somewhere along the ie AB; the point B is in contact with B′, and C with C′.

Two essential points must be emphasized:

1. Under no circumstances must the circumference of the nostril be encroached upon. The shoulders that represent the margins of the nostril must e accurately approximated.

2. The points B and B′ must be as close to the red line of the lip as possible, and must always be on the skin (upper side) of this line."

COMPLICATED HARE-LIP

A. Single complete hare-lip. The alveolus is cleft and one side of the cleft is much more prominent than the other. If possible push the protruding part into alignment with the rest of the alveolus. If this is not possible introduce a mattress suture of wire as shown in Fig. 217, divide the bone at A, push the mobilized bone into proper position and fasten it with the wire.

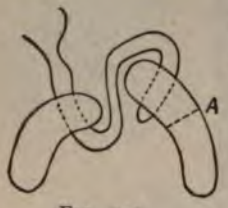


FIG. 217.

B. Double hare-lip complicated by the presence of the intermaxillary bone hanging at the tip of the nose.

Some surgeons advise that the misplaced intermaxillary bone be entirely removed. When this has been done, it is very difficult to secure union between the new-formed upper lip and the column of the nose. Undoubtedly it is wise to retain the bone and replace it in its proper position. An incision (Fig. 218) is made through the muco-periosteum of the nasal septum, beginning immediately behind the intermaxillary bone and extending backwards for ¾ of an inch. A fine periosteal elevator or probe is passed through this incision and the muco-periosteum raised on each side of the septum (Figs. 219 and 220) from its edge up to the root of the nose. With a strong pair of scissors a triangular piece of the septum (Fig. 219) is now excised. This permits the

FIG. 218.
(*Esmarch and Kowalzig.*)

FIG. 219.
(*Esmarch and Kowalzig.*)

FIG. 220.
(*Esmarch and Kowalzig.*)

intermaxillary bone to be easily pushed back into position. It is not absolutely necessary to trim off the mucous membrane covering the intermaxillary bone and those portions of the superior maxilla with which it is in contact, though it is advisable to do so, as union can then take place with rapidity. If any developing teeth are encountered, remove such. Teeth which appear later in bad position are to be treated by a dentist. Suture of the bone in position is unnecessary. The cleft in the lip should be united at the same sitting.

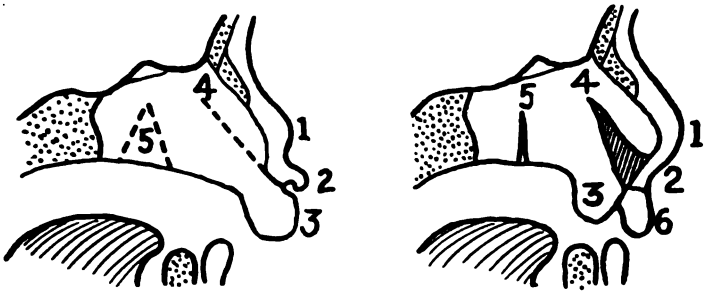
Sometimes instead of excising a wedge from the septum it is sufficient to make a vertical cut through it and slide that portion of the septum anterior to the cut back alongside the posterior portion (Fig. 220). Lane thoroughly disapproves of all these attempts to replace the intermaxillary bone.

If the intermaxillary bone has been dislocated backwards by any of the means described, Reich ("Zent. für Chir.," 1911, No. 25) remarks that it forms "a blunt and bull-dog nose." He has endeavored to overcome this error.

Reich's Operation. Step 1.—Dissect the philtrum from the intermaxillary bone and, in doing so, expose the edge of the cartilaginous septum immediately above the intermaxillary bone. With straight scissors divide the nasal septum obliquely upwards and backwards as high as possible (Fig. 221). This cut divides the mucosa, periosteum and perichondrium, cartilaginous septum and the perpendicular plate of the ethmoid and leaves in front of it, and separate from the rest of the septum, a plate of bone and cartilage reaching from the root to the tip of the nose, guaranteeing its profile.

Step 2.—Subperiosteally excise a wedge of the septum as in the preceding operation but much farther back. Push the intermaxillary bone into correct position.

Step 3.—Close the hare-lip in the usual manner, using the philtrum nasi to form the cutaneous septum of the nose (Fig. 222).



FIGS. 221 AND 222.—1. Point of Nose. 2. Philtrum of nose. 3. Intermaxillary bone. 4. Oblique section of septum. 5. Wedge of septum removed.

DRESSINGS AFTER OPERATIONS FOR HARE-LIP

Should tension on the sutures be feared, a strip of adhesive plaster may be placed from cheek to cheek across the upper lip, in such a way as to relieve tension. If, however, the soft parts of the lip and cheeks have been sufficiently separated from the bones at the beginning of the operation, then such a measure is unnecessary and undesirable, as it simply irritates the already irritable patient. It is not necessary to apply any dressing to the wound, as nature soon seals it with dried blood-clot. Until the sutures are removed there should be as little interference with the wound as possible. If it is going to heal, it will heal under the scab, and the best-intentioned endeavors to clean the wound will merely interfere with nature's work and do no good, as cleanliness can never be attained in such cases. Care must be taken so to fix the little patient's arms that scratching of the wound is rendered impossible.

When it is desired to close the cleft in the palate, which almost invariably accompanies extensive hare-lip, such closure ought to be effected either at the same time as the intermaxillary bone is replaced or at a former operation.

CHAPTER XV

CLEFT PALATE

The proper time to operate for cleft palate is when the patient is under three months of age; Brophy's method of operating is inapplicable in children of over six months. Brophy has operated on 211 cases of cleft palate in babies younger than six months without a single death, yet the operation is undoubtedly not without risk. The operation should be performed before the closure of the concomitant hare-lip. Brophy gives the following reasons for the above practice: (1) The existence of the hare-lip gives more room in which to work. (2) There is less nervous shock after an operation on a child of a few weeks of age than when the babe is older. (3) The bones are soft. (4) After operation the child will be better nourished. (5) The muscles of the palate are given an opportunity to develop instead of atrophy, and the patient does not get into the habit of articulating through the cavern of the nose.

FIG. 223.—(*Brophy, "Dental Cosmos."*)

Before operating see that the patient's general health is good and that no local conditions exist which might interfere with repair. If adenoids are present, they must be removed. For a few days prior to operation it is well to cleanse the mouth and nasal cavity with a saturated solution of boracic acid in glycerin.

Brophy's Operation.—Applicable in children younger than three months; generally possible, though not so easy, in children up to, but not beyond, the sixth month. The only special instruments required are two of Brophy's strong needles (Fig. 223); a few strands of No. 20 silver wire; lead plates No. 17, American gage. No special mouth-gag is necessary, the assistant's fingers being sufficient to keep the mouth open and the tongue depressed. Immediately before operating the writer swabs the parts with adrenalin solution. This lessens hemorrhage. During operation bleeding is easily controlled by pressure with pledgets of gauze wrung out of hot water.

The Operation.—1. Anesthetize the patient. Place in Rose's or the Trendelenburg position. Pass a stout thread through the anterior end of the tongue as a traction suture. This is a great convenience.

2. With a knife pare thoroughly the edges of the cleft in the hard palate, cutting away a little of the bone itself to insure thoroughness. Either pare or horizontally split the edges of the cleft in the soft palate. If split thoroughly, the edges of the split retract and so a good raw surface is left without any loss of tissue.

3. Thread a Brophy needle with a strong silk or celluloid hemp. Raise the cheek and pass the threaded needle through the superior maxilla from without

inwards at a point just back of the malar process and high enough to be *above* the palate (Fig. 224). When the needle appears in the cleft, pick up the thread, which it carries, with hook or forceps. Withdraw the needle, leaving the loop of thread *in situ*. Catch the ends of the thread in a hemostat. Through a corresponding part of the opposite bone pass a loop of thread in the same manner. Pass this second loop of thread through the first and pull the latter out, carrying with it the former. We now have a loop of thread passing through both superior maxillary bones above the palate, and when necessary through the nasal septum. By means of this thread pull a strand of very strong silver wire through the same track.

FIG. 224.—(*Brophy, "Dental Cosmos."*)

4. In the same manner introduce one or sometimes two other silver wires through the anterior portion of the maxilla above the level of the palate (Fig. 224, A).

5. Pass the ends of the silver wire through holes in lead plates moulded to fit the convexity of the buccal surfaces of the bones (one plate on each side). Draw the wires tight and twist them together—*i.e.*, twist the "right end of the anterior wire to the right end of the posterior wire and the same on the left side" (B, Fig. 224).

6. With the thumbs forcibly press the two maxillary bones together until the cleft is completely closed. Twist the wire once more so as to hold the bones firmly together.

7. Close the soft palate by sutures. The state of the patient may necessitate this step being delayed until another day. Do not close the hare-lip until the palate is completely closed and the patient has recovered.

Note.—If closure of the cleft by mere compression proves impossible, division of the malar process may be practised. Make a very small incision through the mucous membrane over the malar process of the superior maxilla. Through this divide the process horizontally, *i.e.*, parallel to the alveolar edge, either with a knife or a small chisel, such as dentists use.

After-treatment consists in as great cleanliness of mouth and nose as can be attained; in the use of stimulants, if necessary; and in feeding by means of a spoon. The plates and wire sutures remain in place from two to four weeks.

In unilateral cleft palate the palatal process of one side has united with the septum of the nose. In such cases the septum is often very much curved, and its lower portion seems a continuation of the palatal process to which it is united. If, in the course of operation, it is difficult to bring the edges of the two palatal processes together, we may cut a groove in the septum at the point X (Fig. 225) and bring the freshened edge of the ununited palatal process (P′, Fig. 225) into apposition with it, thus using a part of the septum to close the defect.

FIG. 225.

Uranoplasty (Arbuthnot Lane's Operation).—For many reasons the operation should be performed as early as possible after birth. Before the milk teeth erupt there is plenty of material present to permit the closure of almost any defect no matter how wide it may be. The large surfaces of bare bone left after Lane's operation heal very rapidly.

Instruments required:

1. Lane's mouth-gags with sharp teeth which bite into the gums. These are sold in pairs of proper sizes (Figs. 226 and 227).

2. Lane's needle holder with very small needles (Figs. 228 and 229). This was originally devised for suture of the bile ducts.

FIG. 226.—(*Lane.*)

3. One small strong knife. A Jones' tenotome will serve admirably.

4. Fine sharp-pointed scissors.

5. One strong hemostat with mouse teeth at the point.

6. Fine strong silk or hemp.

7. A good mouse-tooth dissecting forceps suitable for catching the tissues or the end of a needle.

Type A.—The cleft in the hard palate is unilateral. The septum is continuous with the hard palate on one side. The alveolus and the soft palate are also cleft.

Step 1.—Formation of reflected flap. Make the incision 7, 5, 6, 8 through the muco-periosteum to the bone (Fig. 230). In order to obtain plenty of tissue that part of the incision represented by the line from 5 to 6 is made on the outer surjace of the alveolus near the reflection of the mucosa from the alveolus to the cheek. Make the incision through the mucosa of the soft palate, but do *not* injure the musculature. Reflect the outlined flap 7, 5, 6, 8. The pedicle or hinge of the flap corresponds to the edge of the cleft in the palate.

In separating the muco-periosteum from the bone as the posterior palatine foramen is approached, an elevator pressed in between the flap and the bony palate causes the posterior palatine vessels and nerves to protrude for a considerable length in a tube of periosteum. This is readily grasped by an efficient hemostat, which is left in place until hemostasis is assured.

That portion of the flap taken from the soft palate consists of mucosa and submucosa. It is important not to injure the muscles of the palate. The

reflected flap is formed on the side of the cleft which is *not* attached to the septum.

Step 2.—On the side of the cleft attached to the septum proceed as follows: With forceps pull the uvula and soft palate forwards so as to expose its nasal surface. Divide the mucosa along the posterior edge of the soft palate (4, 3, Fig. 230). Continue the incision across the nasal surface of the soft palate to

FIG. 227.—(*Lane.*)

the point where the soft and hard palates meet at the edge of the cleft (3, 2, Fig. 230). Continue the incision forwards along the edge of the hard palate (2, 1) and across the alveolus (1, 9). The part of the incision affecting the hard palate and the alveolus penetrates the whole thickness of the muco-periosteum. The part of the incision affecting the soft palate only penetrates the mucosa and submucosa. Reflect the mucous flap (2, 3, 4) outlined on the nasal surface of the soft palate. Introduce an elevator through the incision 9, 1, 2 (Fig. 230) and separate the muco-periosteum from the hard palate and to a slight extent from the alveolus near the point 9. Divide the attachments of the soft palate to the hard palate along the posterior edge of the latter, leaving intact the mucosa on the oral side of the palate. During Step 2 the posterior palatine artery remains uninjured.

Step 3.—Turn the flap 5, 7, 8, 6 so that its epithelial-covered surface is directed towards the nose and its raw surface towards the mouth. Tuck the edge of flap 5, 7, 8, 6 well under flap 9, 1, 2, 3, 4, and fix it in position by two rows of fine sutures (Figs. 231 and 233).

FIG. 228.—(*Lane.*)

Type B.—The cleft is wide; the septum is not attached to the palate; the alveolus is not cleft.

Step 1.—Make the flap 1, 2, 3 (Fig. 234) as in Type A.

Step 2.—On the opposite side make the incision 6 through the muco-periosteum along the edge of the cleft. Make the incision 7 and 8 on the nasal surface of the soft palate and reflect a flap of mucosa from the soft palate as in Type A. Separate the muco-periosteum from the hard palate and divide the attachments of the soft to the hard palate along the posterior edge of the latter, leaving intact the mucous membrane on the oral surface.

Step 3.—Turn flap 1, 2, 3 over, with its epithelial surface directed towards the nasal cavity, so as to cover the cleft. Tuck the free edge of this flap well under the flap 10, 6, 7, 8. The triangular portion of this latter flap which was obtained from the nasal surface of the soft palate assists greatly in providing a thick new velum palati.

Step 4.—Suture the edge of flap 1, 2, 3 to the base of flap 10, 6, 7, 8 (Fig. 235). Suture the edge of flap of 10, 6, 7, 8 to the raw surface of flap 1, 2, 3 (Fig. 235).

Note.—If the lower or free edge of the nasal septum extends to the level of the cleft, attach it to flap, 1, 2 and 3 in the following manner after completing Step 2 as described: Make an incision (4, Fig. 234) through the mucosa and periosteum or perichondrium along the middle line of the septum with two small transverse incisions (5) at either end, and turn down laterally the narrow flaps so formed, leaving the cartilage or bone bared and exposed. By placing flap 1, 2, 3 in correct position, the line along which it will rest on the septal margin can be readily defined. Along the line of contact with the septal margin denude the surface of flap 1, 2, 3 with a sharp knife. By a series of sutures perforating flap 1, 2, 3 and the margin of the septum if it be not too hard, or the flaps of muco-periosteum if the edge be bony, securely fix the flap to the septum (1, Fig. 235). Proceed to Step 3.

Type C.—Double cleft palate. Premaxillary bone (P, M, Fig. 236) well in front of the alveolar arch and fixed to the under surface of the nose; the mesial segment (L) of lip is fixed to the anterior surface of the premaxilla. Operation by means of reflected and pivoting flaps. (The following description is in Lane's own words.)

FIG. 229.—(*Lane.*)

"The reflected flap is obtained by an incision extending from 1 along the outer aspect of the alveolus, through 2, and on to 3, when it bends inwards along the free margin of the soft palate to the uvula 4. The pivoting flap is obtained by an incision from 5, along the outer aspect of the alveolus, through 6, along the margin of the cleft in the hard palate from 7 to 8, along the upper surface of the soft palate 9, and then to 10.

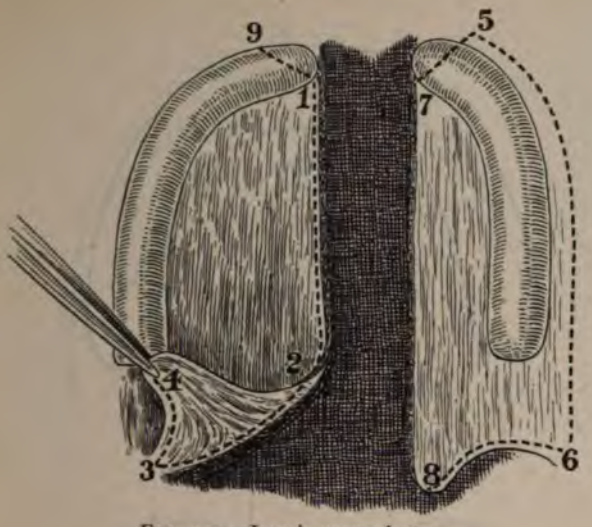


FIG. 230.—Lane's uranoplasty.

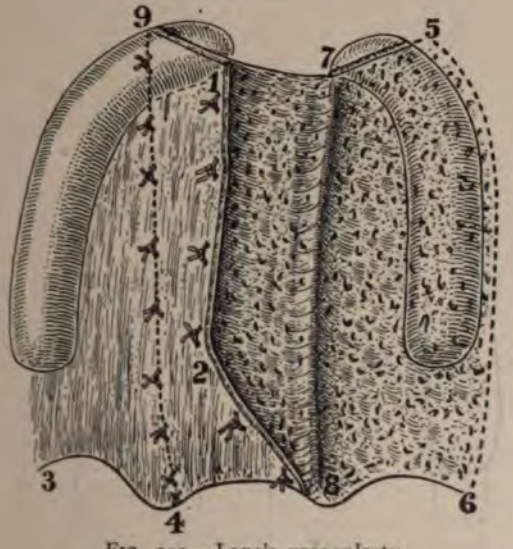


FIG. 231.—Lane's uranoplasty.

FIG. 233.—Lane's uranoplasty.

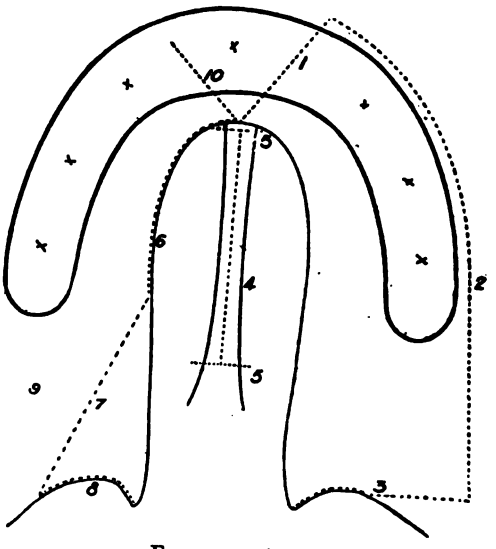


FIG. 234.—(*Lane.*)

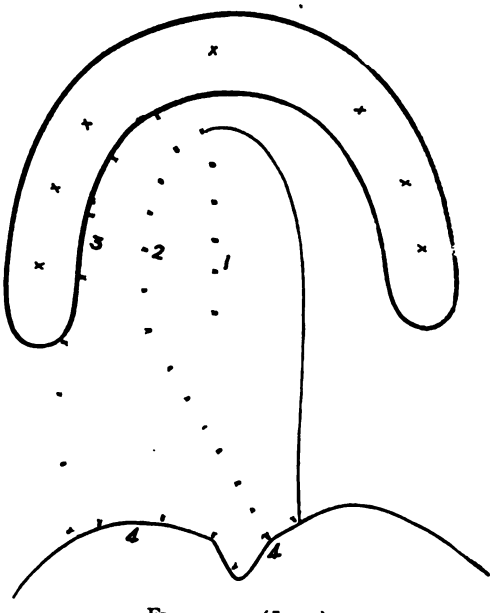


FIG. 235.—(*Lane.*)

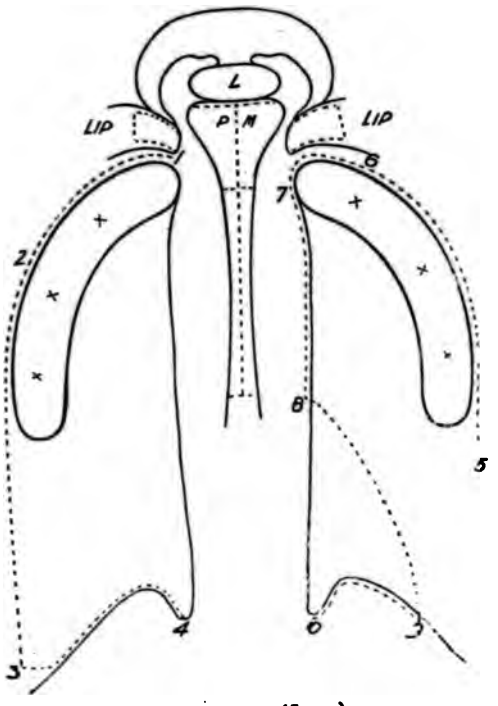


FIG. 236.—(*Lane.*)

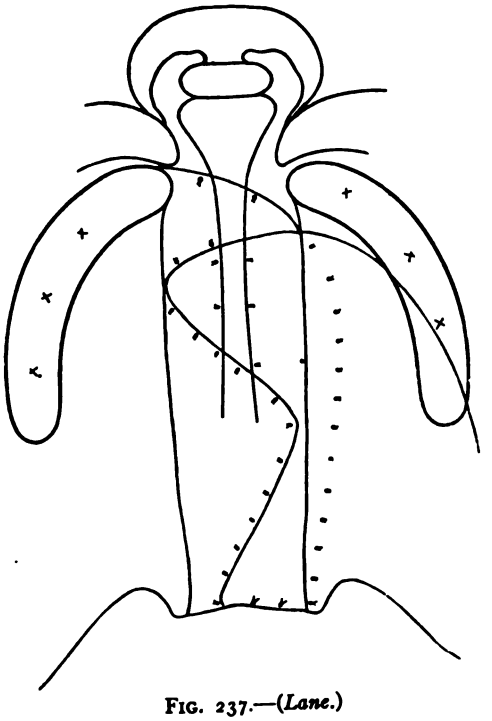


FIG. 237.—(*Lane.*)

"The area of mucous membrane corresponding to the triangle 8, 9 and 10, is raised and reflected inwards. The area of muco-periosteum included in 5, 6, 7 and 8 is raised from the subjacent bone, except at the point of entry of the posterior palatine vessels and nerves, which form the pivot on which this flap rotates. The mucous membrane is striped from the premaxilla and from the free edge of the septum in the manner indicated by the dotted lines, showing incisions in the diagram.

"Large flaps are cut from the portions of lip forming the edges of the cleft, and great care is taken that they have an extensive attachment at their bases. The mucous membrane covering the lateral and lower aspects of the piece of lip lying in the front of the premaxilla is removed (L).

"The reflected flap is first put in position; the mucous membrane, where it comes into contact with the under surface of the septum, having been rendered raw, is secured to it by sutures. The pivoting flap is then moved inwards upon the reflected flap, to which it is united firmly by a double row of sutures. Finally the soft palate is closed in a similar manner. This is represented in Fig. 237.

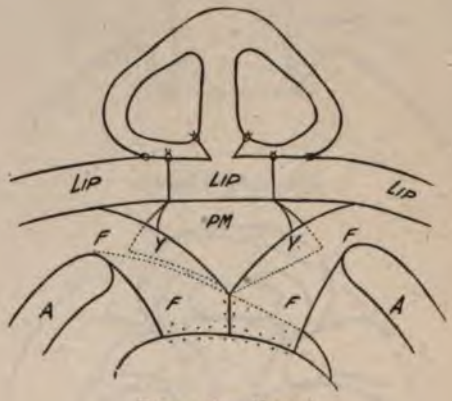


FIG. 238.—(*Lane.*)

"After this the triangular areas of muco-periosteum which were reflected from the premaxilla are fixed in position (see Fig. 240), where these are indicated by Y. The flaps from the lips shown as F, F are arranged with their raw surfaces upwards. These are united to the raw surfaces of the flaps from the premaxilla and of the reflected flap, and are also sutured by their margins to one another and to the free edge of the pivoting flap (see Fig. 238).

"Lastly, the ala of the nose is cut away from the cheek on either side and is displaced inwards where it is united by sutures to the septum, and is sewn to the cheek in its new position. This I have attempted to indicate in the same diagram. Having brought the edges of the lip into accurate position by means of separate sutures, two sutures of linen thread are passed in the manner indicated in Fig. 239. The needle perforates the lip from behind, and is made to re-enter the anterior aspect of the lip through the same hole, and after traversing the lip transversely it again emerges and enters through the same hole, the needle passing directly backwards through the lip. When this thread is made taut and tied the opposing raw surfaces of lip are held in accurate

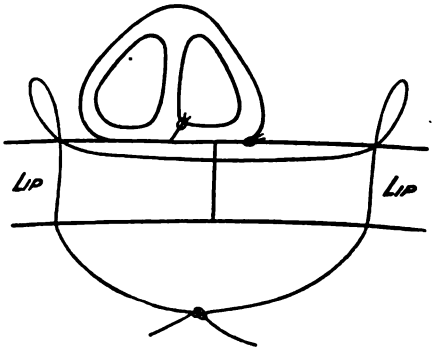


FIG. 239.—(*Lane.*)

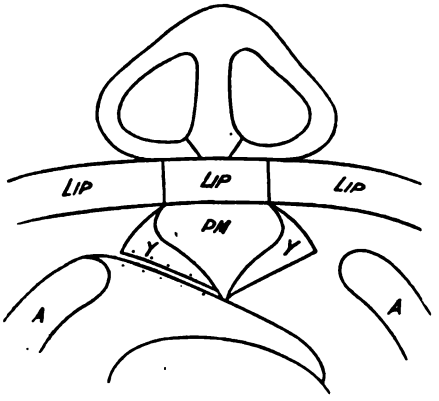


FIG. 240.—(*Lane*)

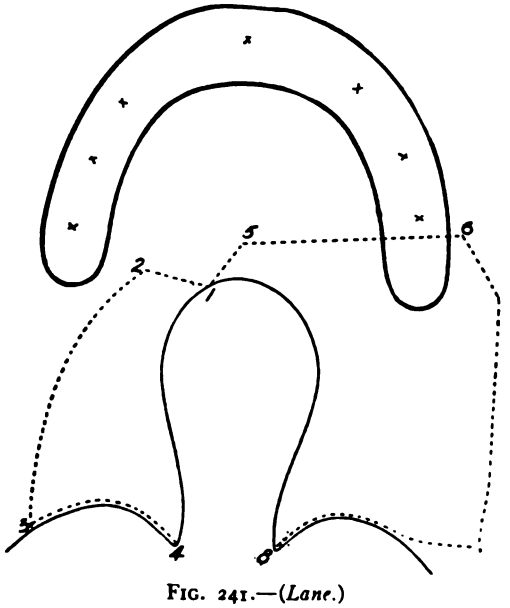


FIG. 241.—(*Lane.*)

position, and no scar whatever results from the presence of these deep sutures, which can be readily removed when they have served their purpose. In Fig. 239 only one cleft in the lip is represented."

Type D.—Wide cleft of soft palate.

Step 1.—Reflect the flap 1, 5, 6, 7, 8 (Fig. 241) with its base at the edge of the cleft.

The flap consists partly of muco-periosteum from the hard palate and laveolus and mostly of mucous membrane from the soft palate and cheek. The flap must be large enough to easily cover the defect. Do not injure the musculature of the soft palate.

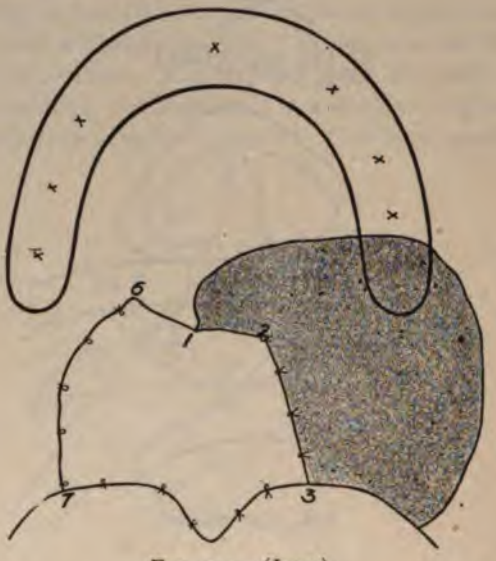


FIG. 242.—(*Lane.*)

Step 2.—From the *nasal* surface of the soft palate on the opposite side of the cleft reflect the flap 1, 2, 3, 4 with its base at the edge of the cleft.

Step 3.—Suture the two flaps together one over the other in an overlapping fashion (Fig. 242).

After the milk teeth have erupted some modification of Lane's methods or the following classical operation may be selected.

The patient having been anesthetized, placed in Rose's position, and a traction thread passed through the tongue, a suitable gag is introduced. Of the numerous gags invented, probably Lane's or Whitehead's is the best, but the writer finds that a piece of wood about ¾ inch thick answers every purpose, and consequently rarely uses anything else.

1. *Denudation.*—Seize the end of the uvula on one side with a sharp hook or forceps (Fig. 243). With a sharp knife or tenotome remove a strip of mucous membrane from the whole edge of the cleft. In cutting, do so obliquely, removing rather more membrane from the oral than from the nasal side of the palate. This gives a more extensive raw surface, which is a great advantage. When the soft palate is very thick, its edge may be split instead of pared. Repeat the process on the other side of the cleft.

2. With a suitable periosteotome or knife divide the muco-periosteum along the edge of the cleft in the hard palate. Separate all the muco-periosteum

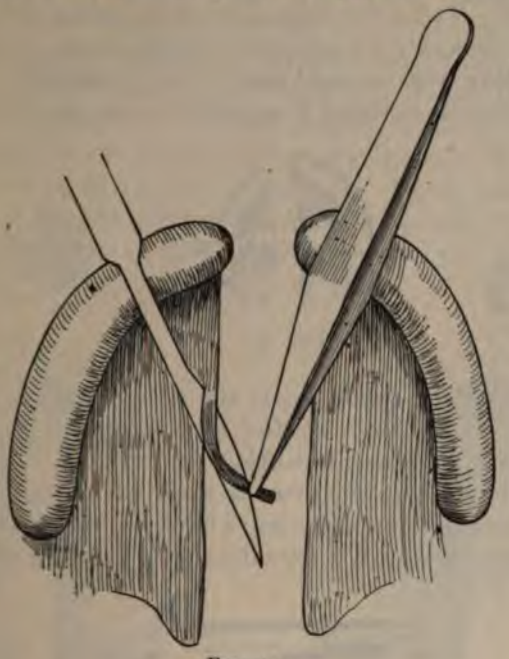


FIG. 243.

from the hard palate up to the alveolar process (Fig. 244). For this procedure Brophy's periosteotomes (Fig. 245) are convenient, but a suitable instrument is easily extemporized from a dental spatula or even an aneurysm needle.

FIG. 244.

3. The soft palate may be said to consist of three layers: (*a*) The nasal mucous membrane; (*b*) the tissues attached to the posterior edge of the hard palate; (*c*) the oral mucous membrane.

Leaving intact the oral mucous membrane, which is continuous from hard to soft palate, divide transversely with fine curved scissors both the nasal mucous membrane and the tissues attached to the posterior edge of the hard palate. This is one of the most important steps in the operation, allowing the muco-periosteal flap obtained from the hard palate to drop towards the mouth, and with it the soft palate (Fig. 249). Repeat this procedure on the opposite side. Commonly the raw edges of the flaps thus obtained will come into apposition without tension. If they do not, it is necessary to make a lateral incision through the muco-periosteum parallel and close to the alveolus (Fig. 247) on one or both sides of the

FIG. 245.—(*Brophy, "Dental Cosmos."*)

mouth, and extending from the lateral incisor back to the posterior margin of the hard palate. If this is insufficient to relieve tension, Billroth's procedure may be adopted as follows: Pass a fine chisel through the posterior angle of the lateral incision, direct it obliquely inwards and upwards against the hamular process, and with a light blow from the hand make it divide that bone. The dislocation of the hamular process, increased if necessary by the use of an elevator, gives

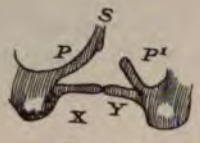


FIG. 246.

FIG. 247.

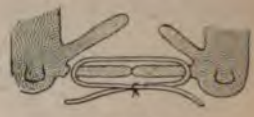


FIG. 248.

perfect relaxation of the velum palati and does not injure its musculature. *Incisions through the soft palate dividing its muscles* were formerly considered necessary; *now they are never admissible.*

C. H. Mayo considers it important to make lateral incisions (Fig. 247) on both sides. Outside the posterior palatine foramina, these do not merely relieve tension, but permit the use of a relaxation tape. Having prepared the parts

FIG. 249.

N. M. Nasal mucosa. H. P. Hard palate. O. M. Oral mucosa. S. P. Soft palate. S. Line of section.

for the insertion of sutures, and having made two lateral incisions close to the alveoli, he introduces a narrow tape which surrounds the right and left muco-periosteal flaps (Fig. 247). Traction on the ends of the tape brings the flaps towards the operator, steadies them, and facilitates the introduction of the ordinary sutures. When the sutures are in place and tied, Mayo crosses the free ends of the tape and fixes them by tying a ligature around them at this

FIG. 250.

point (Fig. 248), cuts off the superfluous portions of the tape, and lastly slides the whole tape until that part fastened by the ligature lies in the nasal instead of in the oral cavity. The tape fastened as above acts as an efficient relaxation suture or support; it also drains secretions from the nasal cavity into the mouth. It is remarkable how this very simple contrivance facilitates the operation. Harry Sherman smears the tape with Mosetig's bone wax and fastens its free ends together by sutures.

. Suture. Many special needles have been devised to overcome the ulties met with in closing palatal defects. Of these, the Deschamps 250) is perhaps the best, although it is usually made too large. The r finds that he can discard such special instruments by using very small, urved needles, grasped in a long-necked needle-holder, and passing each end e thread, armed with a needle, from the nasal to the oral side of the palate, from within outwards. The usual method of suturing is to begin at vula and work forwards, being careful to *evert* the edges of the wound when laps from the hard palate are being united. Silk or waxed linen are the rials used. If the soft palate has been split instead of pared, Sherman es the nasal surface first (knots being on the nasal side) and then the oral ce.

. 251.—(*Brophy, "Dental Cosmos."*)

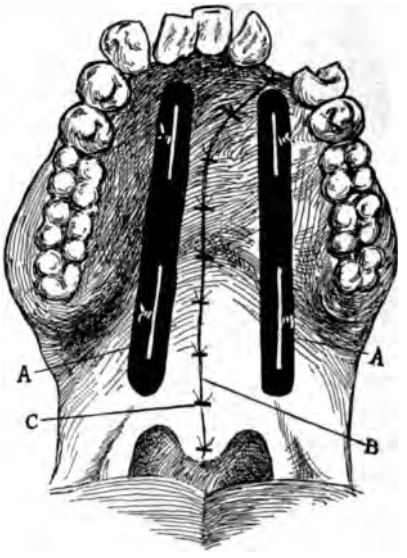


FIG. 252.—(*Brophy, "Dental Cosmos."*)

arry Sherman (Journ. A. M. A., Dec. 1, 1917) as a preliminary measure vors to narrow the cleft by means of pressure applied as follows:
om a point opposite the top of the ear apply a strip of adhesive plaster e cheek to a point on the upper lip just external to the side of the nose. s on both cheeks. Have a hook on the outer surface of the anterior each adhesive strip. By an elastic band uniting the two hooks it is compress the superior maxillæ. Other surgeons, *e.g.*, Brown (Oral Dis- Malformation) apply adhesive tape across the lip from cheek to cheek s means obtain narrowing of of the pro- maxillary bone in d ssure

The lower incision should be at the junction of the smooth mucosa of the undersurface of the tongue with the papillary mucosa of the dorsum. The dorsal incision must be made internal to the tissue it is desired to excise. The smooth infralingual mucosa being preserved makes an excellent flap for the reconstruction of the margins of the tongue (Fig. 256).

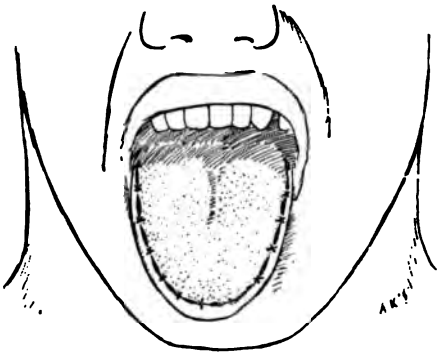


FIG. 256.—The operation completed. (By permission from the *British Journal of Surgery*.)

When a small tumor exists near the tip of the tongue, it may be removed by means of a V-shaped incision.

Dieffenbach's Operation.—Local anesthesia usually suffices. If a general anesthetic is used, the mouth must be kept open during the operation by a mouth-gag. Pull the tongue forwards by means of a volsellum or a stout

FIG. 257.

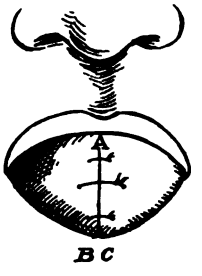


FIG. 258.

thread passed through its tip. At a point on each side of the tumor and about ¾ inch from it, pass a long silk thread through the whole thickness of the tongue in such a manner that the loop of the thread is under the tongue while its two free ends emerge from punctures on the dorsum (Fig. 257).

Excise the tumor and a wedge-shaped portion of the whole thickness of the tongue by the converging incisions A B, A C (Fig. 257). The excision is most easily effected with the scissors. The bleeding is now liable to be sharp. Tighten and tie the suture which has already been introduced. This stops the hemorrhage. Introduce a few more stitches so that the wound is neatly closed (Fig. 258).

The only after-treatment required is frequent cleansing of the mouth with poisonous antiseptic washes.

Excision by Elliptical Incisions.—Small tumors of the tongue may be excised under local anesthesia by means of elliptical incisions surrounding them. Soon as the neoplasm is removed, bleeding is stopped by the application of w sutures which at the same time close the wound.

The treatment of lingual thyroids is discussed on page 216.

COMPLETE REMOVAL OF THE TONGUE

As a preliminary to any operation for extirpation of the tongue it is necessary lean the mouth. The mouth, especially in cases of cancer, is a filthy cavern. teeth, usually decayed, are covered with tartar and other abominations. mouth should be thoroughly washed with antiseptic solutions, the teeth rously brushed, or, better, cleansed by a good dentist, and loose teeth should removed. Very many methods of operating have been devised, but only w of them will be described.

1. **Whitehead's Operation.**—The following description is taken almost rely from an article by Whitehead:

1. The patient should be placed in a sitting posture; the head, firmly held, ld be inclined forwards so that the blood may escape easily. The light must ood and have direct access to the mouth. The patient's mouth and the eon's axilla should be at about the same level.

2. During the first stages of the operation anesthesia should be complete, afterwards only partial insensibility should be maintained.

3. A good gag is essential. It must be one which will not slip and will not arrass respiration. [Whitehead's gag, with the tongue depressor absent, robably the best.] With this the mouth is opened as widely as possible.

4. A strong ligature should be passed through the tip of the tongue for the ose of traction.

5. The tongue is retained within the mouth principally by means of the um and the attachments to the anterior pillars of the fauces. These and reflection of the mucous membrane between the tongue and jaw must be led with scissors. Should any spouting vessels be seen, they must at once aught in forceps and twisted; general oozing of blood may be neglected, use as soon as the main arteries are discovered and twisted all bleeding s. "There is, in reality, no difficulty in determining the actual position e lingual arteries, as they are practically invariably found in the same tion and it requires very little experience to seize them with a pair of forbefore dividing them." The rest of the tongue may be cut away without sity. Before completely removing the tongue it is wise to pass a ligature ugh the glosso-epiglottidean fold. This ligature may be left in place for ty-four hours, and permits one to pull forwards the epiglottis should ration be interfered with at any time. Traction on this ligature of itself ts hemorrhage and makes it an easy matter to secure any bleeding vessel.

6. Wash the wound with an antiseptic solution.

7. Paint the wound with iodoform styptic varnish. The varnish is made by substituting for the alcohol ordinarily used in the preparation of Friar's balsam a saturated solution of iodoform in ether 9 volumes, and turpentine 1 volume.

After-treatment.—Encourage the patient to sit up and move about even as early as the day following the operation. Give liquid food by the mouth as early and freely as possible. If necessary, supplement oral feeding by the use of nutrient enemata. The mouth is frequently washed and the varnish is reapplied daily.

In the hands of Whitehead this operation has had remarkable primary results. Up to 1891 he had performed it 66 times with but three deaths.

When it is necessary to remove only one-half of the tongue, the operation is practically the same as above, except that the organ is split in the middle line and the diseased half alone excised.

II. Regnoli-Billroth Operation.—*Step* 1.—Pass a stout thread through the tongue for purposes of traction.

FIG. 259.—Regnoli-Billroth operation. (*Esmarch and Kowalzig.*)

Step 2.—Make an incision through the skin and subcutaneous tissue from the anterior margin of one masseter muscle to the anterior margin of the other masseter. This incision follows the lower edge of the lower jaw (Fig. 259). Reflect the skin-flap thus outlined. The submaxillary region now lies exposed. If more room is desired, the posterior ends of the original incision may be extended backwards to the angles of the lower jaw.

Step 3.—With scissors or knife penetrate the mouth from below upwards immediately behind the symphysis. Be careful not to injure the periosteum. Separate the structures composing the floor of the mouth from the lower jaw as far back as the anterior pillars of the fauces. Any bleeding vessels are caught up by forceps and either twisted or ligated. The tongue with its traction thread is pulled out through the sub-mental wound and its posterior connections divided with scissors.

Step 4.—If there is hemorrhage from the stump and it is not easy to locate the bleeding point, hook the forefinger into the pharynx and pull forwards. This simple manœuvre brings the whole stump within reach and the hemorrhage is easily controlled by forceps or suture. A few sutures of silk-worm-gut judiciously inserted lessen the extent of raw surface.

Step 5.—Put an iodoform gauze drain in place and close the remainder of the wound with interrupted silkworm-gut sutures.

During this operation all affected or suspected lymphatic tissue must be removed from the submaxillary region.

III. Sedillot's Operation.—In cases of lingual cancer where the floor of the mouth and the jaws are not affected, Kocher ("Operationslehre," fourth

edition) strongly advocates Sedillot's operation. The only disadvantage of the procedure is that excision of affected or suspected lymph-glands, etc., if done at the same time as the primary operations, leaves too large and irregular a wound, so that infection can scarcely be avoided. Kocher recommends that the glands be excised at a second operation. Supposing that the disease affects the edge of the tongue posteriorly and has spread to its base, to the anterior pillar of the fauces, the soft palate, and the lateral wall of the pharynx, the operation is carried out as follows:

FIG. 260.—Excision of tongue.

Median division of the lower lip, chin, and skin in submental region as far as the hyoid bone (Fig. 260). Hemostasis. Division of the lower jaw in the middle line. Separation of the divided halves of the jaw with sharp hooks. Median division of the geniohyoid and genioglossal muscles. By means of a traction thread pull the tongue out and towards the sound side. Divide the mucous membrane of the floor of the mouth backwards at the margin of the tongue. This exposes the lingual vein, running backwards and outwards over the lateral surface of the hyoglossus; also the lingual nerve near the border of the tongue, immediately under the mucous membrane. The hypoglossal nerve is exposed at the outer surface of the hyoglossus, over which it runs inwards and forwards. Between the hyoglossus and genioglossus lies the lingual artery, easily recognized and tied. Divide the hyoglossus with the cautery (Kocher divides all the muscles around the tumor with the cautery). Put great traction on the tongue and, using the cautery, divide the mucous membrane posteriorly, along a line remote from the disease. If the disease extends to the palate and pharynx, divide the styloglossus muscle, and with it the glossopharyngeal nerve. After dividing the mucous membrane in front of the tonsil it can be lifted up by blunt dissection, even when diseased, until the internal pterygoid muscle is exposed. Divide, with the cautery, the soft palate so far as it is diseased, and with it the tensor and levator palati muscles. Now divide the mucous membrane on the posterior wall of the pharynx as far as the longus colli muscle and forwards to the base of the tongue. All this can be done under full guidance of the eye. Lastly, with the cautery, divide the tongue itself, remote from the disease, and sever its nerves, muscles, and vessels (after applying ligatures), or such of these as penetrate the neoplasm. Preserve as many nerves and muscles as possible so as to interfere with deglutition to the minimal extent. Ability to swallow is the greatest preventive against subsequent pneumonia. Rub the wound with a small amount of xeroform. Wire the divided jaw. Do *not* elevate the periosteum when drilling the bone. Close the wound in the soft parts, providing for gauze drainage immediately in front of the hyoid bone. If the patient is placed in the Trendelenburg position, the operation can be done under a general anesthetic without any preliminary tracheotomy. The operation is suitable for all cases except those in which the jaw is affected.

After-treatment.—Until the patient is able to sit up, he should be kept in Trendelenburg's position. On the day following the operation he should try to sit up and attempt to swallow tea or wine with water. Nourishment must be administered through an esophageal tube.

IV. Von Langenbeck's method of excising the tongue is very similar to that of Sedillot, and thus requires no special description, except as regards the incision. On the side corresponding to the disease make an incision from the corner of the mouth vertically downwards to the border of the lower jaw, and continue it downwards to the side of the hyoid bone (Fig. 260). The upper portion of the cut divides the lower lip and gum, penetrating to and exposing the lower jaw; the lower or submental portion at first penetrates only the skin and superficial fascia. Through the lower part of the incision excise all suspected glands (lymphatic and salivary) and ligate the lingual artery. Divide the jaw along the line of incision after boring holes for subsequent wiring. With strong hooks separate the segments of the jaw. The tongue and floor of the mouth are well exposed by this procedure and can be dealt with according to the principles already laid down.

FIG. 261.—Kocher's operation.

V. Kocher's Method.—In certain cases of extensive carcinoma, and always when the disease involves the lower jaw, Kocher advises the following operation:

Step 1.—Put the patient in Trendelenburg's position. Pass a stout thread through the tongue for purposes of traction.

Step 2.—Beginning immediately below the symphysis of the lower jaw, make an incision downwards to a point a little above the hyoid bone; from here cut backwards to the anterior margin of the sternomastoid. Once more change the direction of the incision and continue it upwards along the margin of the sternomastoid to a point near the level of the lobe of the ear (Fig. 261).

Step 3.—Reflect upwards the skin-flap thus outlined.

Step 4.—Excise, *en masse* if possible, all the enlarged glands under the upper end of the sternomastoid and under the angle and horizontal ramus of the jaw. Carefully dissect free the anterior border of the sternomastoid, exposing the carotid packet of vessels and the great horn of the hyoid. Excise the glands in this region.

Step 5.—If the cancer affects the floor of the mouth, the fauces, or jaw, it is wise to ligate the facial vein and the external carotid artery.

Step 6.—Expose clearly the anterior belly of the digastric through its whole length, and ligate the veins under it. From below upwards dissect free the packet of glands exposed until the entire posterior belly of the digastric and the stylohyoid muscles lie free in the posterior inferior part of the wound. Detach the mass of glands (lymphatic and salivary) from the lower jaw.

Step 7.—At the posterior end of the great horn of the hyoid divide the insertion of the hyoglossus muscle. This exposes the lingual artery. Tie the artery, but preserve the hypoglossal nerve.

Step 8.—The lower surface of the mylohyoid muscle now lies exposed and on it the mylohyoid nerve. At the posterior margin of the muscle penetrate the mouth (guided by a finger in the mouth) after once more noting the extent and limits of the disease. Beginning at this opening, divide the oral mucous membrane along a line remote from the disease. Attend to hemostasis.

Step 9.—Divide the lingual muscles at the hyoid and remove all infiltrated tissue. It is easy to pull the tongue out through the wound as soon as the oral mucous membrane has been divided.

If a preliminary tracheotomy has been done, the entrances to the larynx should be packed with sterile gauze as soon as the pharynx is opened.

After-treatment.—Leave the lower part of the wound open so that the laryngeal pack may be changed frequently. Every time the dressings are changed (and this must be done very frequently) administer plenty of nutritious food by means of an esophageal tube. As long as the mechanism of deglutition is seriously disturbed keep the patient in more or less of the Trendelenburg position except when he stands or sits up. As long as deglutition is poor the patient must not lie horizontally; he must either sit up or lie with his head and shoulders low. The object of this care is, of course, to avoid pneumonia from the entrance of secretions into the air passages.

The question as to whether the last-mentioned operation should or should not be preceded by a tracheotomy is much discussed. Kocher and Jacobson are strong advocates of this as a preliminary.

The advantages of tracheotomy are the possibility of easy anesthetization; of plugging the pharynx with gauze, thus avoiding inspiration of blood, and of greater freedom in operating.

Butlin advocates preliminary laryngotomy as a safe and convenient substitute for tracheotomy.

When removal of the whole base of the tongue is not necessary Crile passes closely fitting rubber tubes through the nares into the pharynx, to a point opposite the epiglottis, pulls the tongue well forwards and then closely packs the pharynx with gauze. The two tubes after emerging from the anterior nares are connected by a Y, of glass or metal, to a single tube and through this the anesthetic is administered.

The opponents of preliminary tracheotomy believe that this operation, while decreasing the danger of pneumonia from inspiration of blood, yet makes the patient subject to a greater danger of contracting pneumonia from other causes. If tracheotomy is decided on, it should be performed several days before the tongue is attacked, to permit the patient to become accustomed to the new conditions of respiration before his powers are taxed by the very severe operation he is to undergo.

VI. Butlin's Method.*—(A) The disease does not involve the floor of the mouth.

Perform a preliminary laryngotomy (p. 232).

Pack the pharynx to prevent blood gravitating into the larynx.

Step 1.—By Whitehead's method or some modification thereof, remove the

*Butlin, "Op. Surg. Malignant Dis.," second. ed., "Brit. Med. Jour.," Feb. 15, 1905.

local disease with ¾ inch of apparently healthy tissues around it in every direction. Where the disease is on the border of the tongue, it is best to remove that half of the tongue to an inch behind the cancer.

After about nine days, when the patient is able to take plenty of liquid food, proceed to Step 2.

Step 2.—Make an incision along the anterior border of the sternomastoid from near the mastoid process to the sternoclavicular articulation. Make an incision from the *symphysis menti* to meet the previous incision, just above the thyroid cartilage. Reflect the two triangular flaps of skin thus outlined and expose the platysma myoides and fat of the anterior triangle of the neck.

Step 3.—Beginning *below*, expose the sternomastoid and retract it backwards. Expose the carotid packet of vessels, dissecting from below upwards, and separate from it every particle of fat, whether superficial or deep, anterior

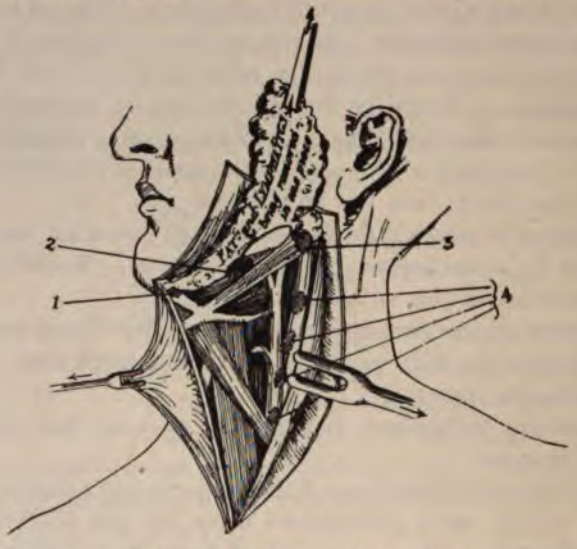


FIG. 262.—Butlin's method for excision of the tongue.

Sketch indicating the position of the most important lymph nodes, all of which are supposed to have been dissected out and removed. 1. Location of submental group lymph nodes. 2. Location of submaxillary group lymph nodes. 3. Location of parotid group lymph nodes. 4. Location of carotid group lymph nodes.

or posterior. Be careful to remove the fat between the parotid and the vessels. All this fat ought to be left attached to that of the rest of the anterior triangle, otherwise the operation is liable to be incomplete (Fig. 262). Working from the region of danger (carotid packet) and from below upwards, remove *en masse* all the fat in the anterior triangle and with it the submaxillary salivary gland, leaving the muscles quite bare. In the submental region complete the dissection by searching between the geniohyoid muscles, lest a gland be overlooked.

If the disease involves the contents of the carotid packet, these must also be removed. The internal jugular vein more often requires removal than does the carotid artery.

Step 4.—Place one strip of gauze in the submaxillary triangle beneath the jaw and another between the parotid and the vessels. Bring the ends of

ɔut at the lowest part of the wound. Provide tubular drainage also.
vound. Damage to the parotid will permit a leakage of saliva, but
in a few days.

inciples of Butlin's operation are: (1) Operation in two stages is
· than in one. (2) The glands are involved very early in lingual
: the lymphatic vessels between the primary lesion and the secondary
:ape.

ıtlin's results have been so remarkable that no apology is necessary
ıcing the statistics of seventy cases in which he was permitted to
he operation in the manner he advocates. A study of Butlin's
and drawings gives great encouragement in the treatment of cancer
ue even when apparently advanced:

s of seventy cases in which the contents of the anterior triangle
ved:

ɔperation	6
after operation	1
rence in the mouth	9
rence, uncertain where (in one of these the glands could not be entirely re- operation abandoned)	7
rrence in the glands (in one of these the submaxillary salivary gland was . the disease recurred beneath it; in the other seven cases the glands were at the time of their removal, and in five of these they were demonstrably is)	8
er on the opposite side of the tongue	1
tion of glands on opposite side of neck	2
r disease within three years	1
untable (operation too recent)	11
ses	24
	70

ccessful cases are calculated on the seventy cases, after deducting
ɔuntable (11), the patient who died within three years of another
, and the patient who was not traced after the operation (1), leaving
cases, with twenty-four successful cases = 42.01 per cent.

ɛ of the patients operated on showed that ten of them were over 65
ge, and one over 70 years (77).

ses of death from operation were:

etc. (both from mouth and neck in a badly alcoholic patient)	1
(from the sudden falling back of the root of the tongue some days after n)	1
ɔonia	4
	6

e disease involves the floor of the mouth to such an extent that the
operation is impossible.

e the tongue by any of the methods already described, and according
lition of the patient remove the glands of the neck either at the same
sequent séance.

Whatever operation is chosen for removal of lingual cancer, it is always of prime importance to remove *en masse* the whole of the related lymphatic territory, even if the primary lesion appear trivial and the lymphatics show no macroscopic involvement.

Crile ("Journ. Am. Med. Assoc.," Dec. 1, 1906) reports remarkably favorable results from an operation similar to, but more extensive than Butlin's.

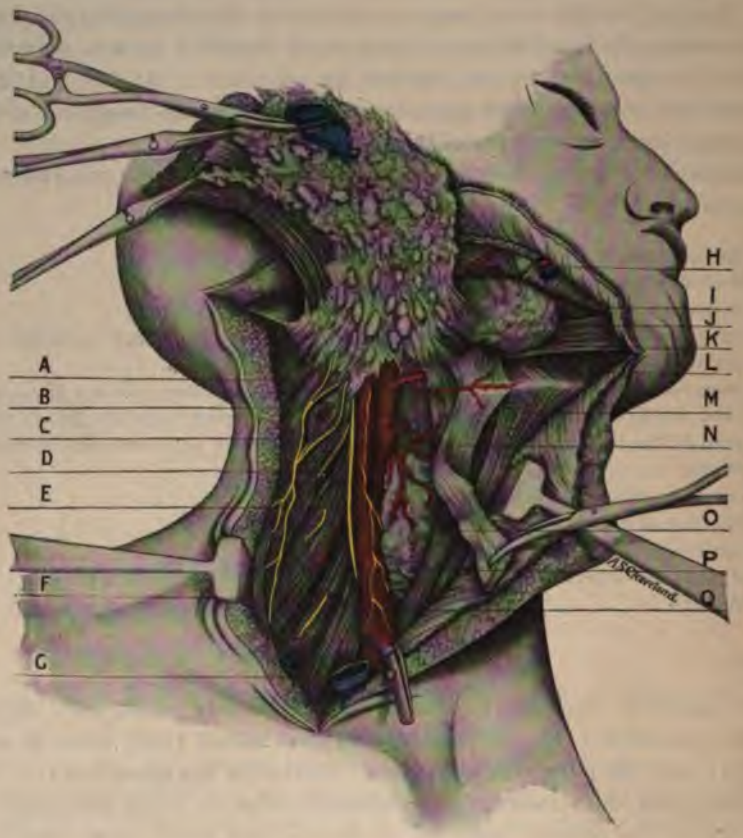


FIG. 263.—(*Crile.*)

The entire mass of lymphatic gland bearing tissue is excised *en bloc*, and handled as little as possible This dissection becomes easy when followed in the deep plane. The entire block of tissue is finally divided above, including the vein. A, splenius. B, hypoglossus descendens. C, spinal accessory. D, elevator ang. scapuli. E, pneumogastric. F, scalenus posticus. G, internal jugular. H, facial vein and artery. I, submental. J, submaxillary. K, digastric. L, mylohyoid. M, sternohyoid. N, omohyoid. O, thyroid gland. P, thyrohyoid. Q, carotid.

When lymph nodes are palpably enlarged, further metastasis is sure to be irregular, therefore Crile removes the whole lymphatic-bearing tissue on the affected side; when there are no palpably enlarged glands he only removes the lymphatics next in order.

In operating on the former class of cases Crile temporarily compresses the common carotid with his special clamp, doubly ligates and divides the internal jugular vein low down in the neck and excises the vein along with the lymphatic tissues, and the muscles of that side of the neck (Fig. 263).

George E. Armstrong performs what is practically the Butlin operation. He begins by exposing the cervical lymphatic territory on both sides of the neck, ligating both external carotid arteries and excising the lymphatics exactly as does Butlin. After providing for drainage and closing the large cervical wounds he *immediately* proceeds to excise the tongue. When only one lateral half of the tongue is removed he finds it very advantageous to stitch the remaining half to the floor of the mouth. In this way nearly all the raw surfaces are covered.

VII. Maitland's Operation.—Maitland ("The Australasian Med. Gazette," Oct. 20, 1906, describes a thorough operation which has given him much satisfaction and which he practises in all except *very early* and *very late* cases. Fig. 264 shows Maitland's incisions. The following paragraphs are copied from the article to which reference has been made.

"*Dissection of the Digastric Triangle.*—A clean dissection is then made of this triangle, beginning at the point of the chin and working outwards and upwards, paying particular attention to the spaces between the outer edge of the mylohyoid and the hyoglossus, as glands are easily overlooked in these situations. The anterior layer of the outer portion of the deep cervical fascia, which here forms a compartment for the submaxillary gland, is opened, the glands pulled forwards, the facial artery tied and divided, the common facial and anterior division of the temporo-maxillary veins having been previously tied and divided. The dissection of this anterior portion of the digastric triangle is then completed by carrying the dissection well up over the body of the mandible, so as to remove the lower of the facial glands. That portion of the digastric triangle posterior to the stylo-maxillary ligament containing the parotid is next cleared and the lower portion of the parotid is removed. This dissection is carried sufficiently deep to remove the deep parotid glands; this step has been insisted on by Butlin. I have regularly carried it out for some years.

"*Division of the Sternomastoid.*—Before this step in the operation is performed the dissection of the anterior triangle is begun from before backwards till the anterior border of the sternomastoid is reached. The muscle is then divided at the level of the omohyoid, the lower portion being turned down.

"*Dissection of the Anterior and Posterior Triangles.*—The dissection of these two triangles is then proceeded with from below upwards, cleaning all the fascia off the vessels. The dissection is carried on right up beneath the parotid, the dissection being completed by removing the sternomastoid muscle at its insertion, together with the contents of the anterior and posterior triangles. By this means the whole of the deep descending cervical chain of glands is removed.

"*Removal of Internal Jugular Vein.*—This is done as the last step of the operation; if it be done earlier in the operation much valuable time is lost in stopping venous hemorrhage. I am firmly of opinion that only by removing the sternomastoid muscle can the deep cervical chair of glands be thoroughly removed. The internal jugular vein I do not always remove, as with the removal of the sternomastoid muscle, as I suggest, the vein can be more thoroughly cleared both on its anterior and posterior aspects.

"*The Effect of Removal of the Sternomastoid Muscle.*—All the movements of the head are, as I show you from these cases, thoroughly carried out by the post-rotators, and the removal of the muscle practically in no wise interferes with the head movements. The text-books advise preservation of the muscle, because of the supposed interference with the movements of the head; but this view I know to be erroneous.

"*The Division of the Spinal Accessory.*—This is done in nearly every case, and only in two instances have I seen drooping of the shoulders; the third and fourth cervical are sufficient to preserve the function of the muscle."

VIII. A. P. C. Ashhurst's operation is sufficiently described by illustrations 264, 265 and 266 (Annals of Surg., Aug., 1915).

FIG. 264.—Maitland. (*Australasian Med. Gaz.*)

IX. Spischarny's Suprahyoid Operation. (Archiv für klin. Chir., xcii, p. 1212).—*Step* 1.—Make a transverse incision above the hyoid bone from one sternomastoid to the other. If necessary enlarge the wound by longitudinal incisions along the sternomastoid muscle. Remove the lymphatic glands and with them the submaxillary salivary glands, if the floor of the mouth is affected. Ligate and divide both lingual arteries. Divide both hypoglossal nerves.

Step 2.—Separate the root of the tongue from the hyoid bone and open the pharynx in the angle between the tongue and the epiglottis (Fig. 267). All the diseased structures (even, if required, the tonsils, pillars of the fauces and floor of the mouth) can now be isolated under guidance of the eye.

Step 3.—Open the mouth and through it divide the anterior attachments of the tongue. Remove the tongue.

Step 4.—Suture together the remnants of muscles attached to the chin and the hyoid bone. Carefully reunite the digastric muscles to the hyoid. Close the wound leaving a narrow canal to the pharynx for purposes of drainage.

Pass a soft œsophageal catheter through the nose into the œsophagus to permit feeding during the first few days.

Spischarny states that preliminary tracheotomy is unnecessary if the operation is performed in Rose's position.

X. Vallas' Transhyoid Operation.—When cancer is limited to the base of the tongue near the epiglottis, or when it affects the epiglottis, **Vallas' operation of transhyoid pharyngotomy** gives good access to the parts. This operation is

FIG. 265.—The neck dissection has been completed, the cervical lymphatics and fat still attached to skin flap. The neck wound is then tamponed with gauze. (*Ashhurst, Annals of Surgery.*)

FIG. 265A.—The cheek has been turned aside, exposing the tongue. The left anterior pillar of the fauces has been divided, and the scissors are now dividing that on the right. (*Ashhurst, Annals of Surgery.*)

FIG. 266.—After removal of tongue, floor of mouth is covered partially by suturing mucosa cheek across alveolus to stump of tongue. A hemostat is on the right lingual artery in the or of the mouth. (*Ashhurst, Annals of Surgery.*)

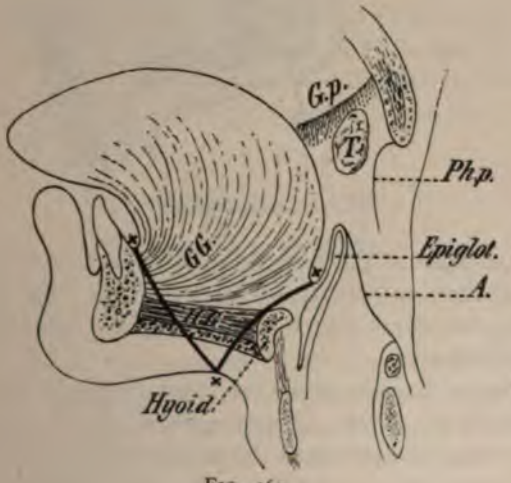


FIG. 267.

also suitable for the removal of foreign bodies and the treatment of syphilitic strictures. Preliminary tracheotomy is not essential.

The Operation. Step 1.—Make a median incision through the skin and subcutaneous tissue from the symphysis of the lower jaw to the superior angle of the thyroid cartilage.

Step 2.—With blunt or sharp dissection separate, in the middle line, the fibres of the mylohyoid muscles in such fashion as to expose the upper border of the hyoid bone in the median line.

Step 3.—With scissors or bone forceps divide the hyoid bone in the middle line. Retract the halves of the bone along with the fibres of the mylohyoid muscle. This gives us a space 1½ inches in width.

Step 4.—The lower part of the wound is separated from the pharynx by the thyrohyoid membrane, the upper part by the mucosa. To reach the pharynx, divide the thyrohyoid membrane; to reach the base of the tongue or floor of the mouth, cut upwards. Access has now been gained to the seat of the disease. It is unnecessary here to describe over again the removal of the neoplasm; it must be done freely on the principles already enunciated. Having completed the excision, close the wound, providing drainage at its lower end. No special suture of the hyoid is required.

XI. Abadie's Operation.—The carcinoma affects the floor of the mouth superficially—has spread to the tongue and to the alveolar mucosa anteriorly

FIG. 268.—(*Journ. de Chir.*)

the muscles of the floor of the mouth are not involved. Abadie's operation may be valuable ("Arch. provinciales de Chir.," xx, 725; Ref. "Journ. de Chir.," April, 1912). Fig. 268 shows diagrammatically a case suitable for the operation and the lines of incision.

Step 1.—Make an incision along the lower border of the inferior maxilla from one masseter to the other. Dissect upwards so as to separate all the soft parts from the front of the jaw until the mouth is freely opened along the line of reflection of the mucosa from the jaw to the lips. Reflect upwards as a visor the flap thus formed.

Step 2.—According to the extent of the lesion select the two extreme points of the line of section of the bone (A and B, Fig. 269). At these points perforate

the bone with a drill. With an amputation saw divide the bone along the line AB. Pass a Gigli saw through the perforation at B and divide the alveolus along the line BC. Do the same at perforation A.

Step 3.—Seize the mobilized segment of bone with lion-jawed forceps and pull it upwards and forwards. With scissors cutting horizontally from before backwards, dissect up the disease on the floor of the mouth, then cutting upwards and forwards excise the disease from the tongue along the lines shown in Fig. 268. Attend to hemostasis.

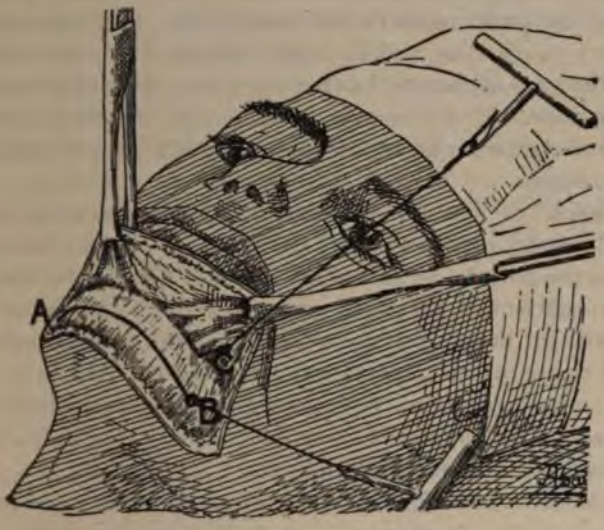


FIG. 269.—(*Journ. de Chir.*)

Step 4.—Close the wound in the tongue with sutures. Unite the mucosa of the tongue to that of the lip. Replace the visor-shaped flap of lip and suture the skin wound after providing for drainage. Before, during, or after Abadie's operation, the lymphatic territory ought, of course, to be cleared of its glands and fat as in any other operation for cancer of the tongue.

CHAPTER XVII

PAROTID GLAND

From the standpoint of operative surgery tumors of the parotid may be divided into two classes:

1. Those which are encapsulated inside the gland. This encapsulation may not be perfect, but there is no general infiltration of the gland by the disease. Such tumors are the adenomata and the mixed tumors of feeble malignancy.

2. Those tumors which filtrate the gland substance. Such are the sarcomata and carcinomata.

The principles of operation which may be applied to both classes of tumors alike are: (*a*) early operation; (*b*) free exposure of the growth by suitable incisions; (*c*) careful hemostasis.

When the tumor is one of those encapsulated within the gland, it should, if possible, be enucleated with its capsule, leaving the gland as little injured as is practicable. When the capsule cannot be removed with the growth, it should be removed afterwards as thoroughly as circumstances permit. The facial nerve must be preserved. An incomplete operation often gives good results, but completeness must always be the aim. When the tumor is of the infiltrating type, the *whole* gland with its fascial coverings or capsule must be removed, and with it any adherent skin. Little attention may be given to the facial nerve; its destruction is almost certain. T. Carwardine and Gunn have each preserved the facial nerve in such operations. The necessary dissection must take very much time and in feeble patients this constitutes no mean risk. As in the case of cancers located elsewhere, too much rather than too little must be done. If the surgeon believes that the whole growth cannot be removed, it is better to abstain from operation. An incomplete operation is worse than useless.

I. Enucleation of Parotid Tumors.—(A) The tumor is small, mobile and apparently easily removed: Make a horizontal incision over the prominent portion of the growth, parallel to the course of the fibres of the facial nerve and of length sufficient to permit of removal of the tumor under guidance of the eye and without bruising of the wound. Incise the gland substance so as to expose the tumor, which must now be shelled out. Attend to hemostasis; in doing this, suture-ligatures involving the gland substance should be avoided, as they are liable to constrict branches of the facial nerve and salivary ducts. Close the wound with or without drainage.

(B) The tumor is not large and not suitable for the simple procedure described above:

Step 1.—Beginning at the tip of the mastoid process, make an incision downwards along the anterior edge of the sternomastoid, to the level of the angle of the lower jaw; from this point cut forwards and upwards, in a curve, over the ascending ramus of the jaw, until a flap is outlined which when elevated will expose most of the tumor. The flap consists of skin and superficial fascia alone; no deeper structures must be involved because of the facial nerve.

Step 2.—The growth of the tumor inevitably pushes aside and spreads out the glandular tissue in which it lies. Examine the exposed surface for that part least covered by glandular tissue. The tumor capsule will generally be seen at once; if not, expose it by dividing *horizontally* any overlying glandular substance. If the capsule is strong, proceed to do an extracapsular enucleation by blunt dissection. Any bands of tissue passing to the capsule from its surrounding must be doubly ligated and divided. First free the anterior border of the tumor, then the posterior, and dissect free its deep surface *from below upwards* so as to gain early control of the vascular supply. Proceeding in this fashion, it is often possible to enucleate the tumor *en masse*, but often enough some deeply seated fragments are left behind; such must now be removed individually.

If the capsule is weak and the tumor soft, extracapsular enucleation is impossible. Under these circumstances freely incise the capsule, clean out its contents, and remove the capsule bit by bit as thoroughly as possible. This

apparently very imperfect operation often gives excellent results. With regard to enchondromata of the salivary glands Jacobson writes: "It is not uncommon for branches of the facial nerve to be in relation with the capsule of the tumor, and if this had been much handled, or treated by counter-irritation, they may very likely be firmly adherent. In either case injury to the nerve may be best avoided by slitting up the capsule and shelling out the enchondroma first. The capsule should then be examined to see if any nerve branches are adherent to it; after these have been separated, the capsule itself should be removed. This should always be done to prevent any recurrence, as the peripheral part of these enchondromata is often adherent to the capsule itself." ("Operations of Surgery," i, 340.)

Step 3.—Attend to hemostasis. Close the wound by sutures. Drain dead spaces. Dress.

II. Excision of the Parotid.—Excision of the parotid is necessary in cases of malignant neoplasms, such as carcinoma or sarcoma. As these tumors are infiltrating in character, enucleation is impossible and useless; the whole gland must be removed, whether evidently affected or not.

FIG. 270.—Excision of parotid.

Step 1.—Make a ⊢-shaped incision (Fig. 270) of sufficient extent, through the skin. Reflect the skin so as to expose all the parotid covered by its fascia.

Step 2.—Mobilize the anterior edge of the gland and tumor. Doubly ligate and divide the vessels situated here and Steno's duct. Forceps may be used instead of ligatures during the dissection. Separate the gland from the masseter, working from before backwards, doubly ligating all vessels before dividing them.

Step 3.—Separate the lower edge of the gland (submaxillary portion) from its surroundings by blunt dissection, doubly ligating and dividing the vessels.

Step 4.—Expose the upper end of the anterior portion of the sternomastoid, open its sheath, and retract the muscle backwards. That portion of the sheath adherent to the fascia covering the parotid must be removed with the tumor.

Step 5.—By blunt dissection, working from below upwards and elevating the lower edge of the gland, expose the external carotid artery as it passes under the stylohyoid and digastric muscles. Doubly tie and divide the artery. Mobilize the tumor and gland up to the level of the styloid process.

Step 6.—Separate by blunt dissection all connections between the tumor and the temporo-maxillary joint. Ligate and divide the temporal vessels at the level of the zygoma.

Step 7.—Pull the gland, etc., backwards, expose the numerous veins which run along with the internal maxillary artery, from behind the neck of the lower jaw into the gland. Doubly ligate this leash of vessels and divide them.

Step 8.—Separate by blunt dissection the posterior and pharyngeal connections of the gland, doubly ligating or clamping all vessels before dividing them. In making this last dissection be on the lookout for and avoid injury to the internal jugular vein.

Step 9.—Attend to hemostasis. Close the wound with sutures after providing for drainage.

Any enlarged lymphatic glands near the parotid ought to be removed along with the tumor. The operation is a difficult one, and ought not to be attempted by the inexperienced.

Zarraga's Method. ("Journ. de Chir.," Sept., 1912).—1. From the tip of the mastoid make an incision downwards along the anterior edge of the sterno-mastoid to a point a little below the angle of the lower jaw. Continue the incision forwards immediately below and parallel to the lower jaw until the anterior border of the masseter is reached. Continue the incision upwards along the anterior edge of the masseter to terminate on the zygoma.

FIG. 271.—(*Journ. de Chir.*)

2. Reflect upwards the skin flap thus outlined. This exposes the sterno-mastoid, the facial nerve, the parotid, the masseter and the lower jaw in front of it, the facial artery, the zygoma.

3. With elevator and knife bare the bone of the lower jaw just in front of the masseter and divide it with Gigli's saw. Divide the masseter at its zygomatic insertion. Divide Steno's duct.

4. Grasp the ascending ramus of the jaw with lion-jawed forceps and dislocate it outwards and backwards, at the same time dividing the internal pterygoid muscle, ligating the inferior dental vessels and dividing the tendon of the temporal muscle (Fig. 271).

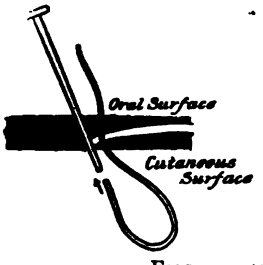
5. Ligate the external carotid immediately before it enters the parotid; ligate the internal maxillary as it passes behind the condyle of the inferior maxilla. Ligate the superficial temporal and the posterior auricular arteries.

land and the ascending ramus of the jaw together. One if the pharyngeal prolongation of the parotid is adherent and if necessary separate the adhesions.

—A salivary fistula most commonly results from disease or ct. In some cases a stricture is present distal to the fistula d, the fistula either closes spontaneously or after its orifice by the cautery or revivified and sutured. When the above inappropriate or has failed, operation becomes necessary. anterior to the masseter muscle.

nbeck's Operation.—Make the proximal portion of the duct of duct next to the parotid gland) prominent by passing a ough the fistula. With a knife or scissors separate the fistula, their surroundings, leaving them attached to the gland. In a on pass the knife from the wound into the mouth, perforating sa. Pull the free end of the mobilized duct into the mouth foration in the mucosa and fix it there with sutures. Close the When applicable, the above is the best operation for salivary ortunately it is not often available, as the unnatural orifice is near the origin of Steno's duct behind the anterior margin of the

e's Operation.—From the fistula make two perforations into the ¼ inch apart. Through these openings pass the two ends of an re, a piece of lead wire, or a stout silk suture. Fasten together he ligature in the mouth so as to exercise pressure on the included



FIGS. 272 AND 273.—Deguise's operation.

. Necrosis of the tissues follows and a permanent opening into the is assured. Freshen the edges of the cutaneous fistula and unite them tures. The elastic ligature or lead wire may best be introduced through a which is made to perforate the cheek from within outwards (Figs. 272, A silk suture is best inserted from without inwards by means of a needle end.

Kaufmann's Operation.—Pass a cannula (about ⅛ inch in diameter) fistula into the mouth and through it introduce a rubber tube or seton. the cannula, leaving the seton in place. Whenever the track of the become covered with epithelium, remove the seton and close the orifice of the fistula.

The fistula is situated in the masseteric portion of Steno's duct.

(A) Either Kaufmann's seton or Deguise's method of double puncture may be used, but neither the seton nor the constricting ligature must perforate the masseter. The puncture or punctures must pass from the fistula to the mouth by tunnelling between the masseter and the skin.

(B) Von Langenbeck's method may be used if a sufficient length of duct remains attached to the gland. In this method it is necessary to puncture the masseter and pull the mobilized portion of duct through the puncture into the mouth. Instead of being punctured, the masseter may be divided transversely, and if necessary a portion of the ascending ramus of the lower jaw may be cut away with rongeurs so that the defective duct may gain access to the mouth.

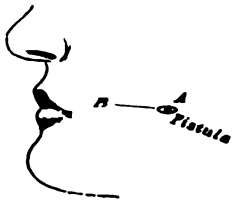


FIG. 274.—Braun's operation.

(C) Plastic formation of a new duct (Braun's operation): Make the incision A, B (Fig. 274). Mobilize the fistulous orifice by dissecting it free from the skin. The incision penetrates all the tissues of the cheek except the mucosa and masseter. Retract the edges of the wound, exposing the outer surface of the mucosa (Fig. 275). From the mucosa construct a flap with its pedicle at the edge of the masseter, of length sufficient to reach from the masseteric edge

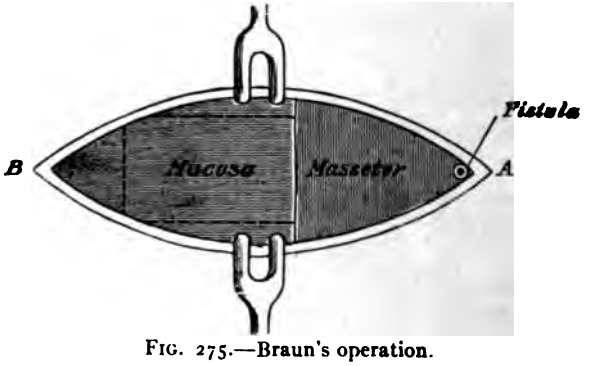


FIG. 275.—Braun's operation.

to the fistula. Turn this flap back over the masseter; suture its free end to the fistula; suture its upper and lower edges together so as to form a tube lined with epithelium (Fig. 276). Close the skin-wound.

(D) *Crouse's Operation.*—This operation is very similar to that of Braun but is simpler and of wider application.

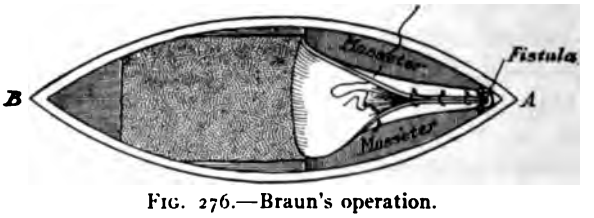


FIG. 276.—Braun's operation.

Step 1.—Make a 3 cm. (1¼ in.) incision through the skin and fat straight downwards from a point 2 cm. below the zygoma and 2 cm. in front of the ear. This avoids injury to nerves and vessels. Expose the fascia covering the parotid and make a 1 cm. incision in it.

FIG. 277.—(*Crouse, Surg., Gyn. & Obst.*)

FIG. 278.—(*Crouse, Surg., Gyn. & Obst.*)

Step 2.—Grasp the lip, turn the cheek out and reflect a flap of mucosa, about ¼ inch wide and thick enough (⅛ in.?) to be reliably viable, beginning near the vermilion line of the upper lip and running back to slightly behind the level of the second upper molar. The pedicle of this flap is posterior.

Step 3.—Introduce a curved hemostat through the external incision on the cheek and pass it forwards hugging the surface of the masseter and force it into the mouth just in front of the pedicle of the intra-oral flap (Fig. 277). Open the forceps and dilate the tunnel. Grasp the end of the flap in the forceps and pull it through the tunnel. Pass a No. 0 chromic gut suture in the Lembert fashion through the mucous surface of the flap near its free end (Fig. 278) and through the posterior edge of the incision in the parotid fascia. Tie the suture but leave its ends long. Pass a fine forceps from the external wound through the tunnel into the mouth and catch with it the middle of a ligature of No. 5 chromic gut. Pull this thread through the wound and tie the long ends of the fine suture to its loop leaving the long ends of the coarse ligature in the mouth. The mucosal flap assumes a tubular form around the coarse ligature. Close the external wound. Crouse has used his operation five times with success (Surg., Gyn. and Obst., May, 1915).

Anastomosis between the Parotid and Submaxillary Glands.—In cases in which lesions of Steno's duct seriously interfere with excretion from the parotid Ferrarini (Zent. f. Chir., 13, June, 1914) has shown the possibility of establishing drainage through a parotid-submaxillary anastomosis.

Expose the submaxillary gland by an incision parallel to and below the horizontal ramus of the lower jaw. Continue the incision back to, and around the angle of the jaw so as to freely expose the lower part of the parotid. Open the capsule of, and mobilize bluntly, the submaxillary gland. Isolate and mobilize the lower end of the parotid behind the angle of the jaw. Make incisions in or pare off corresponding portions of the two glands and suture the raw surface of one gland to the raw surface of the other. Close the external wound. This operation has been an experimental success but has not been used clinically.

Ianni (Internat. Abst. of Surg., May, 1919) advises Leriche's resection of the auriculotemporal nerve to prevent secretion from the Parotid in old cases of fistula where plastic operation is improper. After the auriculotemporal nerve has passed around the posterior surface of the neck of the lower jaw it enters the substance of the upper part of the parotid and passes upwards in front of the auditory meatus behind the temporal artery and vein "in a fibrous sheath which renders its exposure difficult and its isolation troublesome" (Poirier and Charpy). In this part of its course besides supplying branches to the gland it gives off branches which anastomose with the superior terminal branches of the facial nerve.

The Operation.—Beginning at the Zygoma make a vertical incision 3 cm. (1¼ in.) long immediately in front of the tragus, and so expose the temporal artery. Note the extra-glandular portion of the nerve parallel to and behind the artery. Follow the nerve downwards into and through the gland tissue. When it is fully isolated, the portion of the nerve trunk freed from its surroundings is about 4.5 cm. (1¾ in.) long and the small secretory branches which

stimulate the gland are visible. Evulse the central end of the nerve. Secretion continues for some days after operation.

Olivier (Lyon Chir., XVI, No. 2) had perfect results in three cases. He writes that the operation is easy but that the resection must be extensive enough to get all the parotid branches. These branches leave the nerve trunk behind and a little internal to the neck of the condyle so that the dissection must be deep.

CHAPTER XVIII

OPERATIONS UPON THE NOSE

EXCISION OF INTRANASAL MALIGNANT TUMORS

DENKER'S TRANSMAXILLARY METHOD*

Step 1.—With blunt hooks pull the angle of the mouth and the upper lip upwards and outwards. Beginning opposite the wisdom tooth on the affected side make an incision through the gum of the upper jaw to a point near the frenum of the upper lip. The incision should be slightly curved upwards. With an elevator separate the soft parts from the upper jaw until that bone is exposed nearly to the lower margin of the orbit and the pyriform aperture of the nose is laid bare.

Step 2.—With a fine elevator or dissector, beginning at the pyriform aperture, separate the mucous membrane from the outer wall of the lower and middle sinuses of the nose and partly from the floor of the nose. Continue this separation backwards to the posterior limits of the antrum of Highmore. If the lower turbinated bone is not involved in the tumor, remove it with strong scissors. Temporarily pack with gauze for hemostasis.

Step 3.—With chisel and rongeur remove the external bony wall of the antrum of Highmore. If the mucosa lining the interior surface of this wall is healthy incise it freely so as to gain free access to the sinus; if it is involved in the growth, extirpate it with the growth. With chisel and rongeur remove *completely* the inner or nasal wall of the antrum, both the bone and the mucosa.

Step 4.—With scissors or probe-pointed knife remove the mucosa of the outer wall of the nose (already separated in Step 2). If the tumor has arisen from the middle sinus of the nose it generally will come away with the nasal mucous membrane. Free access is now attained to the ethmoidal and sphenoidal sinuses which can be treated according to circumstances.

Step 5.—Pack the wound with gauze. Suture the oral wound. Keep the mouth clean with washes. Remove the pack after three or four days.

The above operation is *not* suitable for cases of tumors arising from the nasopharynx, retro-maxillary or pterygo-palatine fossæ.

* "Münchener med. Wochenschrift," 1906, No. 20.

RHINOPHYMA (ACNE HYPERTROPHICA)

This deforming disease must be treated by operation. If the tumors are pedunculated their removal requires no special description, if they are extensive and non-pedunculated proceed as follows:

Give a general anesthetic.

Step 1.—Through the anterior nares introduce gauze strips and so plug the posterior two-thirds of the nose, leaving the anterior portion free. This prevents the inflow of blood. Plugging of the posterior nares will do as well.

Step 2.—Put the forefinger of the left hand into one nostril as a guide. Make an incision down to but not into the cartilage, all round the growth from the middle line outwards (Fig. 279).

Be sure to leave as much skin as possible near the opening of the nares to avoid subsequent stricture.

FIGS. 279 AND 280.—Rhinophyma. (*Laurens.*)

Step 3.—Seize the median edge of the tumor mass with forceps and entrust these to the assistant (Fig. 280). With knife or scissors shave off all the diseased tissues within the circle of the incision. Attend to hemostasis with forceps, ligature, pressure with hot pads or the thermo-cautery.

Step 4.—Repeat Steps 3 and 4 on the opposite side.

Step 5.—Remove the nasal plugs. Introduce short drainage tubes into each nostril. Cover the wounds with rubber tissue, perforated oiled silk or silver foil. Apply compressive dressings. Field (Journ. A. M. A., June 14, 1919) operates in two sittings—excising first one-half and later the other. He uses skin grafts. The results in time are very good. Skin grafting is rarely necessary. Major Seelig heartily condemns skin grafts as unnecessary and the cause of subsequent disfigurement. He urges that the redundant tissue be *not* shaved off too deeply, otherwise all sebaceous gland rests are removed and no nidusus of epithelium left for formation of new skin.

Angioma of Nose.—Angiomata of the nose are not uncommon and may require no treatment. Often, however, they are so disfiguring as to prevent their possessors from earning a livelihood.

When small, angiomata may be treated by freezing (liquid air, carbon-dioxide snow), by electrolysis, by application of nitric acid, by ignipuncture, etc., but a large, pulsating tumor demands excision. In the patient shown in Figs. 281 and 282 ("Lancet," March 23, 1912), Mr. Battle ligated the external carotid, the superior thyroid and the facial arteries on both sides and then cut away the nasal disease leaving the bony and cartilaginous framework of the nose exposed. About three weeks later the central portion of the lip was excised and later the nasal wound was covered by a flap taken from the forehead in the Indian method. The result was gratifying.

FIG. 281.—(*Battle.*)

FIG. 282.—(*Battle.*)

Epithelioma of Nose.—In order to excise not merely the tumor but at least ¾ inch of apparently healthy tissue all around and in one piece with the lymphatic nodes next in order Henry Curtis (Trans. Royal Soc. Med. Clin. Sect., April, 1914) operated as follows: (The tumor was situated on the left side of the tip of the nose, the submaxillary glands were small and hard); the incision 1–6 (Fig. 283) was made. On the columella the cut penetrated to the cartilage; elsewhere it reached the bone or penetrated the nose and mouth. From the beginning of the original cut in the median line of the upper lip, a second incision was made (1–7) just skirting the red margin of the lip to the left angle of the mouth, and then vertically down (7–8) to reach the lower border of the mandible. The flap outlined by the cuts 8–7–1–2–3–4–5–6 included the entire left nostril, the whole thickness of the cheek and exposed both the nasal and oral cavities.

An incision penetrating the *skin alone* was now made between the points 6 and 8 and the cheek flap was removed with the lymphatics and glands *en masse*. "Those removed consisted of the left maxillary glands, just below the orbit, the lymphatic vessels (and ? glands) in the left buccinator region, both submaxillary, salivary and lymphatic glands, both submental glands, and the

left superficial and deep cervical glands." To expose the glands below the jaw and to provide a flap to repair the defect in the nose and cheek the incisions 8, 5′, 4′, 3′, 2′ were made and the outlined flap was fixed by sutures into its new bed. A split made in the flap (Fig. 283 insert 2′–2″–x) aided in fashioning the new nostril. The wound in the neck was easily closed. The result was satisfactory after some subsidiary patching operations had been done.

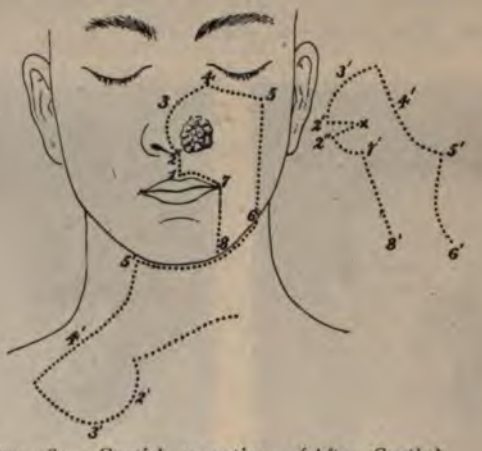


FIG. 283.—Curtis' operation. (*After Curtis.*)

RHINOPLASTY

Rhinoplasty, or the reconstruction of the nose, is called for in cases where the nose has been destroyed by disease or operation. The character of the operative interference required varies with the location and extent of tissue destruction.

I. The destruction is confined to the soft structures of the nose but the osseous and a part of the soft structures of the nose remain.

A. A relatively small portion of the soft parts has been destroyed. Figs. 284, 285, 286, 287 sufficiently explain the correction of this defect.

1. The defect is confined to one ala. Fritz König ("Berlin. klin. Woch.," 1902, No. 7), after thoroughly freshening the nasal defect, implanted into it a properly shaped segment consisting of the whole thickness of the concha of the ear. The result was excellent.

2. The defect extends beyond the ala but is still lateral.

Langenbeck's Operation.—From the sound side of the nose reflect a skin-flap, which has its base near the inner angle of the yee of the affected side (Figs. 288 and 289). Suture the flap thus obtained to the edges of the defect, which have, of course, been vivified immediately before. Cover the raw surface left by the elevation of the flap with Thiersch's skin-grafts.

Nélaton's Operation.—This is similar to the preceding, but the flap is obtained from the cheek (Fig. 290).

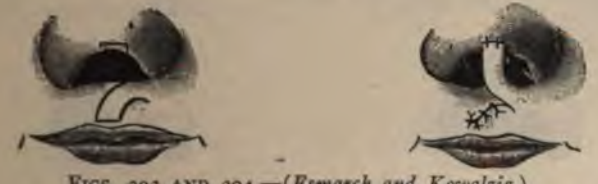
3. The septum is absent.

Dieffenbach's Operation.—Make a flap as outlined in Fig. 291, consisting of the whole thickness of the upper lip. Freshen the distal end of the flap,

FIGS. 284, 285, 286 AND 287.—(*Esmarch and Kowalzig.*)

FIGS. 288, 289 AND 290.—(*Esmarch and Kowalzig.*)

FIGS. 291 AND 292.—(*Esmarch and Kowalzig.*)



FIGS. 293 AND 294.—(*Esmarch and Kowalzig.*)

turn it forwards, and suture it to a vivified area on the anterior edge of the nasal opening (Fig. 292). Close the wound in the lip.

Langenbeck makes a flap from the skin of the upper lip, leaving the deeper structures intact (Figs. 293 and 294).

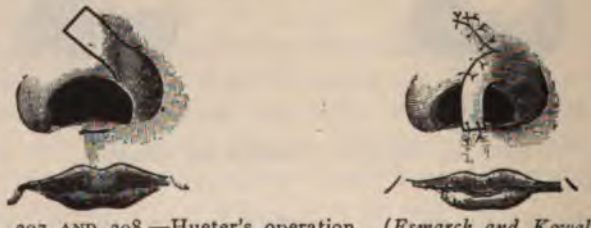
Both of the above methods are faulty in that use is made of very hairy skin, and annoyance is sure to result.

FIG. 295.—Lexer's operation.

Lexer makes a flap from the mucous and submucous structures of the upper lip, leaving the skin intact except for a perforation through which the flap is

FIG. 296.—Lexer's operation.

brought into position (Figs. 295 and 296). Hueter uses a flap of skin obtained from the nose itself (Figs. 297 and 298).



FIGS. 297 AND 298.—Hueter's operation. (*Esmarch and Kowalzig.*)

4. Much of the end of the nose has been destroyed as well as the cutaneous septum and much of the cartilaginous septum: The alæ nasi are drawn up-

wards meeting in a mass of scar tissue attached to the ends of the nasal bones. (La Pr. Med. 23, Jan., 1919.)

Caboche's Operation.—*Step* 1.—Free the remains of the alæ nasi by an incision parallel to and about 3/8 inch from their lower or free margin (Fig. 299), and penetrating the nasal cavity. Where the alæ were adherent to the nasal bones there is much scar tissue. Excise the scar tissue.

FIG. 299.—(*Caboche, La Pr. Med.*)

The result is the formation of two alar flaps (Fig. 302,) with external pedicles and a considerable wound due to the excision of all the scar tissue at the level of the lower part of the nasal bones.

Step 2.—Formation of new septum: (*a*) Much of the cartilaginous septum is present and on it is part of the cutaneous septum. Puncture the septum at a point slightly behind the future pedicle (Fig. 300). From this puncture divide the septum close and parallel to the floor of the nose until the vomer is reached

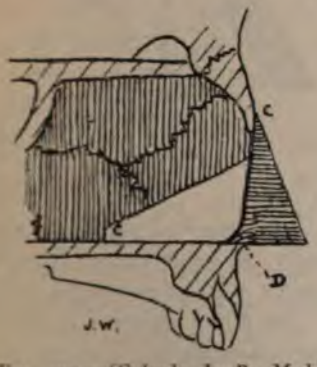


FIG. 300.—(*Caboche, La Pr. Med.*)

FIG. 301.—(*Caboche, La Pr. Med.*)

as demonstrated by increased resistance to the passage of the Septotome. Separate the cartilage from the vomer for a sufficient distance by hitting the handle of the costotome a few blows with the heel of the hand. Divide the cartilage from a point near the nasal bones downwards and backwards to reach the incision already made—meeting it at an angle of about 45 degrees (Fig. 300).

Pull the point of the septal flap forwards and upwards and suture it to the periosteum of the nasal bones.

(*b*) Only the bony septum is present. At the anterior inferior part of the septum separate the muco-periosteum on both sides backwards for 1 cm. and upwards for 2 cm. Continue the separation of this muco-periosteum from the floor of the nose outwards as far as possible. This forms a submucous pocket on each side of the septum, open anteriorly and bounded internally by the denuded septum, inferiorly by the denuded floor of the nose. The postero-superior external boundaries are formed by the mobilized muco-periosteum. Divide the periosteum along its posterior line of adhesion to the floor of the nose thus forming on each side of the septum a rectangular pedicle capable of nourishing the vomer after it is mobilized. Divide the vomer from before backwards along the floor of the nose for a sufficient distance. This is best done with an electric saw. Divide the septum from a point near the nasal bones to the posterior extremity of the incision already made parallel to the nasal floor. Pull the point of the flap upwards and forwards (Fig. 301,) to be inserted between the nasal bones which have been previously separated from each other by a forceps. Perforate the nasal bones and end of septal flap, introduce a wire suture and so fix them together (Fig. 301). As the whole of the operation is very bloody it is wise to have the pharynx packed and to provide for respiration and anesthesia by means of a preliminary laryngotomy (Butlin's) or the use of a pharyngeal tube.

FIG. 302.—(*Caboche, La Pr. Med.*)

FIG. 303.—(*Caboche, La Pr. Med.*)

Step 3.—Make two flaps from the cheeks (Figs. 302 and 303,) sufficient in size to more than cover the nasal defect. Usually the lower end of these flaps will reach to the level of the angles of the mouth while their upper ends or pedicles may be near the orbito-nasal angles. The upper portions of the flaps should have as much subcutaneous fat on them as possible. Do not suture the lower ends of the flap into position for some days. Do not insert any drain or pack into the nose lest the flaps be compressed. Divide the pedicles after about six weeks. Of course as in all rhinoplasties, one or more secondary or modeling operations may be required.

B. Practically all the soft structures of the nose are absent.

1. **Indian Method.**—In this operation a pedunculated flap is taken from the forehead and sutured to the nasal defect.

The Operation.—With oiled silk make a model of the flap required. Figs. 04 to 311 represent variously shaped flaps which have been used.

Step 1.—Place the anesthetized patient in the Rose or Trendelenburg posure. Thoroughly freshen the edges of the nasal defect down to, but not eyond, the points into which the new alæ of the nose are to be inserted. When onsiderable skin exists over the bridge of the nose, Step 1 may be modified dvantageously as follows: From the nasal bridge reflect the flap of skin A, , C (Fig. 313) and turn it down with its epidermal surface directed towards ie nasal cavity. Freshen or pare the edges of the nasal defect as already deribed. When in Step 3 the forehead flap is turned down, its raw surface lies contact with the raw surface of the flap from the nasal bridge, an epidermal ining is provided for the new nose, and thus shrinking is obviated.

Step 2.—Place the oiled silk model on to the forehead, in an oblique position, id with its pedicle so placed as to include the angular artery. Guided by ie model as to shape and size, cut a flap from the forehead. The flap con-

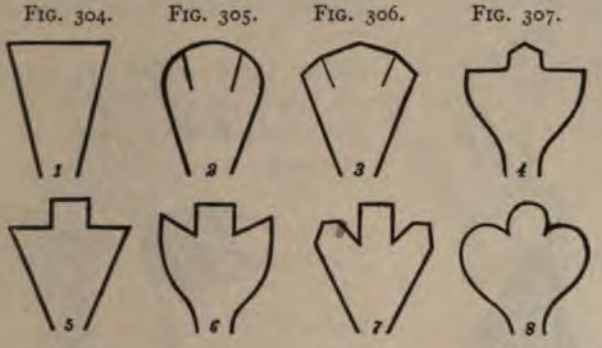


FIG. 304. FIG. 305. FIG. 306. FIG. 307.

FIG 308. FIG. 309. FIG. 310. FIG. 311.

FIGS. 304 TO 311.—(*Esmarch and Kowalzig.*)

ists of all the structures down to the bone. With sutures lessen the size of he defect left in the forehead; cover such open wound as may be left with kin-grafts.

Step 3.—Turn the forehead flap downwards with its epidermal surface forwards, being careful not to twist the pedicle too severely. As this step is being carried out it may be necessary to lengthen the lateral incisions which bound the pedicle. Fig. 312 shows a well-designed pedicle. Attention to the pedicle is of prime importance because too great torsion means interference with the blood-supply, and more particularly with the drainage of the flap. It is wise to make numerous shallow scratches through the epidermis of the flap; these permit of lymphatic drainage. (See chapter on Plastic Operations.) Fold on itself, laterally, that portion of the flap which is to form the new septum of the nares and maintain this fold by one or two stitches (Fig. 314). Fold on themselves the two lower angles of the flap which are to form the alæ of the nose and maintain the folds by means of mattress sutures.

Step 4.—Suture the raw edges of the new alæ of the nose into their proper position in the nasal defect. Do the same with the new nasal septum. Suture

FIG. 312.—(*Esmarch and Kowalzig.*)

FIG. 313.

FIG. 314.

FIG. 315.—(*Esmarch and Kowalzig.*)

FIGS. 316 AND 317.—(*Monod and Vanverts.*)

he rest of the flap in position (Fig. 315). Do not use too many sutures near he pedicle, and in attempts at esthetic effect do not jeopardize the vitality of he flap, which depends on the freedom of the pedicle. If the flap lives and nites in its new position, any defects in the appearance of the root of the nose nay be safely attended to subsequently. Keep the newly formed nasal openngs patent by means of dressed rubber tubes or cigarette drains.

2. **French Method.**—In this operation pedunculated flaps taken from the cheeks are used to repair nasal defect. Figs. 316 and 317 sufficiently describe the operation as performed by Nélaton.

3. **Italian Method.**—Skin for the repair of the nasal defect is obtained from the anterior and inner aspects of the upper arm.

Step 1.—Dissect from the upper arm a flap of skin, with its pedicle pointing towards the elbow. Flex the shoulder and bring the free end of the flap in contact with the vivified edges of the nasal defect. Unite the flap to the nasal defect by means of sutures. With suitable apparatus (Fig. 318) fix the head and arm so that they maintain a constant relationship to each other until union has taken place.

FIG. 318.—(*Monod and Vanverts.*)

Step 2.—When the flap is firmly united to the edges of the nasal defect, divide its pedicle and complete the rhinoplasty by forming the alæ and septum of the nose out of the lower portion of the flap.

II. The destruction of tissue involves both the soft parts and the osseous and cartilaginous supports of the nose.

A. The tip of the nose with its alæ and septum are intact [König (see p. 200), Israel (see p. 201)].

B. The tip of the nose has been destroyed.

Finger Operation.—The bony framework of the nose is absent and the soft structures are more or less destroyed (Fig. 319).

1. By paring and splitting the tissues, vivify the edges of the nasal defect. Preserve as flaps all tissues which may be of use in forming the new nose. Vivify the bone at the root of the nose. Apply warm gauze to the wounds.

2. A. Make an incision through the skin on each side and the whole length of the middle finger of the left hand, carefully avoiding injury to the vessels. Reflect the skin forwards on the palmar side of the wounds for a short distance so as to form a skin flap on each side of the finger. These flaps are reflected only from the sides of the finger; the skin on the palmar surface of the finger is left intact. Form similar flaps on the dorsal side of the wounds. Through the original incisions excise the carpo-phalangeal articulation and divide the flexor and extensor tendons as well as the ligaments of the excised joint, being careful *not* to injure the vessels. Excise the finger nail. Remove the skin from the tip of the finger. Cut off the distal end of the last phalangeal bone.

B. If there is a sufficiency of suitable tissue at the defect to form an epithelial lining for the new nose then, instead of incisions on the

finger, make one median incision and from it reflect flaps of skin towards the sides of the finger.

FIG. 319.—(*McWilliams.*)

FIG. 320.—(*McWilliams.*)

FIG. 321.—(*McWilliams.*)

FIG. 322.—(*McWilliams.*)

3. Apply the cut surface of the bone of the distal phalanx to the vivified bone at the root of the nose and fix it there with sutures.

A. If method A has been adopted in step 2, suture the palmar flaps, with their epidermal surfaces directed towards the nasal cavity, to the deeper parts

kin flaps around the nasal defect. This forms an epithelial lining to nose. Suture the dorsal flaps to the edges of the skin flaps around the fect (Fig. 320). Support and immobilize the hand, arm and head with of Paris as shown in Fig. 322.

f method B, step 2, has been adopted, use the remnants of tissue around l defect to form the epithelial lining for the new nose and cover with the he finger.

fter about two or three weeks ligate the vessels on one side of the base nger through the existing lateral incision; a few days later ligate the on the other side of the finger (McWilliams).

bout four or six weeks after the first operation amputate the finger at of the proximal phalanx. Trim the phalanx suitably, flex it and suture end to a bed prepared for it at the middle of the lower edge of the fect so that it now forms the columella.

FIG. 323.—(*McWilliams.*)

me necrosis of the proximal phalanx often occurs after amputation it wise to defer trimming and implanting it in the nasal defect until is assured (Fig. 323).

fter healing of the implants is complete it may be necessary to perform er of minor plastic operations to make the new prominence or proboscis mate the form of a human nose. Figs. 319 and 320 show a patient of ams before and after operation. Fig. 321 shows the position of the es in the same patient.

ton's Operation.—Ch. Nélaton has devised an ingenious method of sty which requires no description other than that afforded by Figs. 5, 326, 327.

Nélaton's Operation with Transplantation of Costal Cartilage.—*Pre- Operation.—Step* 1.—With oiled silk make a model or pattern of the

flap necessary to cover the new nose with skin. Lay the model on the forehead and mark its outlines with silver nitrate. The best shape and position for the flap are shown in Fig. 328.

FIGS. 324 AND 325.—Nélaton's operation. (*Monod and Vanverts.*)

Step 2.—Without injuring the perichondrium excise by sharp dissection the whole cartilage of the eighth rib. Close the wound. With a knife pare about one inch of one end of the cartilage (the rib end) until it is not more than ⅛

FIGS. 326 AND 327.—Nélaton's operation. (*Monod and Vanverts.*)

inch (3 mm.) thick. This thin portion is destined to form the new column of the nose. Where the pared portion of cartilage joins the unpared portion cut a notch nearly through the cartilage so that it may be later bent in fashioning the nose.

Step 3.—At the middle of the distal end of the flap outlined with silver nitrate on the forehead, make a cut down to the bone. With a director burrow a tunnel under the periosteum from end to end of the flap (Fig. 328). Pass the graft of cartilage into this tunnel in such fashion that its thin or pared end lies subperiosteally near the skin wound and the notch at the junction of the pared and unpared portions faces towards the skin. Close the skin wound. Apply dressings.

After about two months the second stage of the operation may be undertaken.

Second Stage in the Operation.—Step 1.—Make an incision all round the nasal defect except at its lower side (Fig. 328). This cut penetrates to the bone. Reflect the soft parts between the incision and the nasal defect towards the latter (Fig. 328).

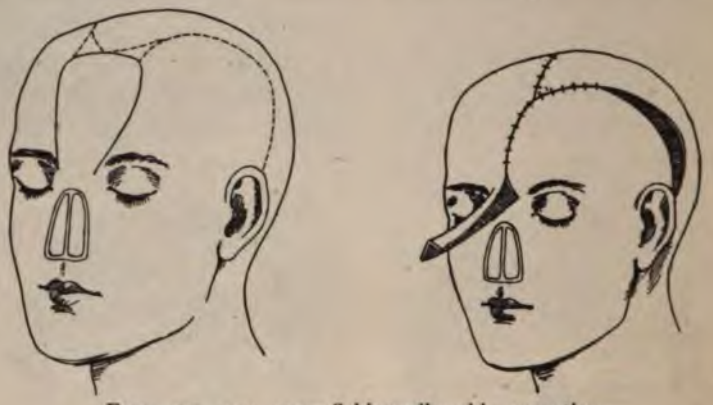
FIGS. 328 AND 329.—Nélaton's operation. (*Laurens.*)

Step 2.—Reflect the flap which was outlined on the forehead at the preliminary operation. (Of course the original marking has disappeared but the model has been kept and the flap has been again traced out with silver nitrate.) The implanted cartilage is an integral part of the flap. Model the distal end of the flap as in Figs. 314 and 329. Gently twist the flap into position and fix it by sutures as shown in Fig. 315.*

Schimmelbusch's Operation.—Practically as in the Indian method, make a forehead flap to cover the defect in the nose, but here the flap consists of the outer table of the skull as well as skin (Fig. 330). Protect the flap with gauze and close the forehead defect, preferably by sliding forwards and inwards large flaps of the scalp, as shown in Figs. 330 and 331. Examine the reflected flap of bone and skin. If the bone is not splintered, cover the whole raw surface at once with Thiersch's grafts, protect the grafts with silver-foil or rubber tissue, and apply gauze dressings. With bandages support the flap against the head and wait until the grafts have become mature. This period of waiting is of value in that the flap becomes accustomed to receiving its nourishment through the pedicle before the pedicle is disturbed by twisting, but as the flap inevitably

*In Fig. 315 the flap has been taken from a different part of the forehead.

shrinks during the delay, it is very necessary that it be made at least one-sixth larger than the defect to be filled. If on examination the bone in the flap is found to be splintered, delay the skin grafting until any necrotic bone is thrown off and the remainder is covered by granulations (four to eight weeks). When the raw surface of the flap is satisfactorily covered with epidermis, make an incision with a fine saw in the middle line through the bone in the flap, so that the flap can now be bent into a ∧ shape (Fig. 331). Mobilize the pedicle of the



FIGS. 330 AND 331.—Schimmelbusch's operation.

flap and twist the latter into position. With sutures unite the edges of the flap to the freshened edges of the nasal defect. When freshening the edges of the nasal defect, it is easy to form flaps of tissue which may be used to form a septum for the nostril (Fig. 332).

E. Lexer's Operation.—As Schimmelbusch's operation is based on König's so is Lexer's on Schimmelbusch's. Lexer ("Archiv für klin. Chir.," xcii, 749) recognizes that after complete rhinoplasty it is most difficult to breathe through the nose because of contraction of scar tissue. Before operation the disease causing the deformity (syphilis, tuberculosis) has caused much destruction of tissue and recovery has taken place by the filling in of ulcerations and defects with granulation tissue which has contracted until the pyriform opening has become small and distorted and nasal respiration is poor. Before attempting to form a new external nose the freedom of the air passage must be assured. The operation is performed in many stages.

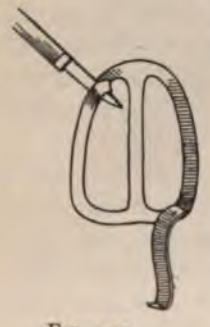


FIG. 332.

First Stage.—Step 1.—With knife, scissors and chisel cut away all scar tissue which deforms the pyriform opening and obstructs respiration.

Step 2.—From the skin around the opening, from remnants of the alæ of the nose, etc., form pedunculated flaps and with these cover the defects resulting from the excision of scar tissue (Fig. 333). These flaps may be held in place by gauze tampons until they become united to their new beds. *No* flaps may be taken from the root of the nose above the aperture; the skin here must be preserved intact for use later.

Second Stage—Preparation of Flap from Forehead.—This procedure is identical with that of Schimmelbusch except that Lexer at once covers the bone in the flap with skin by folding the flap on itself (Figs. 334 and 335). The wound in the forehead should be covered by Thiersch or Wolf skin grafts.

Third Stage.—(Three or four weeks later.)—*Step* 1.—*Formation of pedicle for the forehead flap.*

FIG. 333.—(*Lexer.*)

FIG. 334.—(*Lexer.*)

The flap on the forehead formed in stage 2 was provided with a broad pedicle whose base was on a level with the eyebrows (Fig. 334). Lexer, in several sittings, gradually step by step continues the cuts which outline the forehead flap downwards until they reach on one side the inner angle of the eye, on the other side the nasal opening (Fig. 336). From the latter incision he separates the skin of the root of the nose from the bone until the middle line is reached (Fig. 337) and it becomes possible to twist the pedicle and bring the flap into position without tension.

FIG. 335.—(*Lexer.*)

FIG. 336.—(*Lexer.*)

FIG. 337.—(*Lexer, Archiv für Klin. Chir.*)

Step 2.—From the under surface of the forehead flap reflect a narrow flap of skin to form the septum or philtrum of the new nose (Fig. 337) and through the wound thus made divide the bone in the flap longitudinally so as to fold the bone on itself as in Schimmelbusch's operation.

Step 3.—Freshen the edges of the nasal aperture and suture the forehead flap in proper position as in Schimmelbusch's method.

Fourth Stage.—After several weeks divide the pedicle using its remnants to help to repair the defect between the eyebrows. It is better to delay this

step as long as possible, as when the pedicle is divided the transplanted bone may atrophy, especially in syphilitics.

The result of the operation so far is to provide the patient with a hideous excrescence which an Ananias or an enthusiast might call a nose. Lexer next proceeds to fashion a nose from the excrescence.

Fifth Stage.—This stage is begun a few weeks after the pedicle has been divided.

1. *Formation of a Depression Between the Forehead and the Nose.*—At the level of the eyes divide the scars, in front of the angle of the eye, down to the bone excising any disfiguring scar tissue. The cuts made for this purpose are about 2 cm. long. From these cuts on each side separate the soft parts from the bone and cut away all œdematous and thickened connective tissue (Fig. 338, b).

FIG. 338.—(*Lexer.*)

The subcutaneous excision of scar tissue leaves a superfluous amount of skin and hence it is necessary to convert the lateral linear incisions into ellipses (Fig. 338, b) by excising a little skin from their anterior margins before closing them with sutures.

2. *Formation of the Point of the Nose.*—The tissues about the point of the nose have sunk down and are too voluminous.

On the under surface of the new nose make a semilunar incision which reaches near the base of the *septum nasi* already constructed (Fig. 339, a). Through this incision pass an elevator and raise the skin of the tip of the nose from the underlying bone (obtained from the forehead). Obtain a fresh piece of bone from a rib or tibia of the same patient or from some other person who has required an amputation or resection. Model this fragment of bone into an oval with a shallow groove on its *non*-periosteal side and with somewhat of a convexity on its periosteal side. Push this fragment into the bed prepared for it at the tip of the nose, periosteum towards the surface, in such a manner that it lies, subcutaneously, on the bony support of the new nose and forms a rounded tip to it. The pushing in of the fragment of bone makes

the semilunar incision gape somewhat but this open wound will heal by granulation satisfactorily (Figs. 338, c, and 339, b and c). For a few days it may be necessary to leave a pin *in situ* perforating the fragment of bone and keeping it from being misplaced.

3. *Formation of the Alæ of the Nose.*—The curved incision used for the implantation of bone to form the point of the nose in healing contracts and leaves a small notch which when seen from the side acts as an anterior margin to the lower edge of the alæ. To make this notching more distinct and to make the clumsy lower edge of the new nose thinner, subcutaneously excise through the curved incision, the soft tissues on the inner side of the bony support of the nose and with fine forceps cut out a notch in the bone on each side so as to widen the nostrils (Figs. 338, c, and 339, b). Last of all fashion the outer side of the alæ by excising a small amount of skin as in Fig. 338, d, but in suturing this wound stitch its posterior cutaneous edge *not* to its anterior *cutaneous* edge *but* to the subcutaneous tissue in front of the wound, thus obtaining a more or less sightly indentation.

III. The destruction of tissue involves only the osseous and cartilaginous framework of the nose, the surface being left intact.

a b c

FIG. 339.—(*Lexer.*)

Finney's Operation.—*Step* 1.—Cut away the nail and its matrix from the ring finger of the left hand. Remove the skin from the back of the finger up to its middle joint. Denude the tip of the finger completely, leaving the tip of the bone bare. Stop bleeding.

Step 2.—Introduce a tenotome into the nose and divide all the cicatricial connections between the retracted tip of the nose and the frontal and superior maxillary bones. Pull the soft parts of the nose forwards into the best possible position. Do not cut the skin. Vivify the inner surface of the dorsum of the nose in the middle line.

Step 3.—Introduce the prepared ring finger into the nose in such fashion that the tip of the exposed phalanx lies in contact with the nasal process of the frontal bone and the raw surface of the dorsum of the finger is in contact with the raw median surface of the inside of the dorsum of the nose. Hold the finger in position with stitches uniting the edges of the finger wound to the free border of the tip of the nose.

Step 4.—Hold the hand in position by means of adhesive strips and plaster of Paris for too weeks.

Step 5.—(Two weeks later). Disarticulate the finger at the metacarpo-phalangeal joint. Apply dressings.

Step 6.—(One week later than Step 5). Split the tissues in the middle

line over the nasal spine of the superior maxilla. Flex the finger at the proximal phalangeal joint. Insert the free end of the proximal phalanx into the wound made over the nasal spine of the superior maxilla and fix it there with sutures.

The proximal phalanx forms the column of the nose; the two other phalanges form the dorsal support. Later some minor operations will be necessary to narrow the new column of the nose and to improve appearances.

König's Operation.—This operation was originally devised for the correction of saddle-nose, but it is also of great value in the treatment of cases where the soft parts are absent as well as the hard. The operation as here described is that done for saddle-nose; the modifications required when the soft parts are absent are so self-evident that they will not be mentioned.

Step 1.—Make a transverse incision across the seat of the saddle (A, B, Fig. 340). Pull the tip of the nose down into correct position.

FIGS. 340, 341 AND 342.—König's operation.

Step 2.—From the forehead turn down the vertical flap D (Figs. 341 and 342) and suture its free extremity to the point C at the tip of the nose. This flap is ½ inch wide and is made by cutting through the soft parts with a knife, introducing a chisel through the upper part of the wound, and thus elevating a long narrow strip consisting of skin, periosteum, and the outer table of the skull. The bone in the flap gives firmness to the new nose.

Step 3.—After the Indian fashion, reflect from the forehead, a skin-flap E, F, G (Fig. 341), and turn it down so as to cover the nasal defect A, B, C (Figs. 341 and 342), as well as flap D.

The results obtained from this operation or some of its modifications have been very satisfactory.

Author's Method.—This is suitable in cases where the nasal bones and the surface structures are intact but all the cartilaginous septum has been destroyed.

Step 1.—Without injuring the perichondrium excise by sharp dissection thin strips of cartilage from eighth rib. The strips should be about 1½ inches

long, ¼ inch wide and ⅛ inch thick. Preserve these in warm salt solution. Close the wound.

Step 2.—With a tenotome introduced either through the skin or, as in Finney's operation, through the nose, divide the cicatricial connections of the nose to the pyriform aperture. Pull the nose forwards into as good position as possible.

Step 3.—Introduce a tenotome through the skin in the middle line of the nose just below the osseous nasal bridge. From the puncture make a tunnel between the skin and the mucosa on each side down to the junction of the nasal alæ and the upper lip, where the skin is again perforated. With an eyed probe or a forceps pull a thread and by means of the thread pull a strip of cartilage through each tunnel. Do not permit the ends of the cartilage to protrude through the skin punctures. The strips of cartilage act as splints or braces for the nose. Of course it is easy to introduce a strip of cartilage at any place where it will do most good.

Israel's Operation.—This is merely a modification of König's method, but gives better cosmetic results. The flap D (Fig. 342) is made narrow, being only about ⅛ inch wide, and when turned down and its free end sutured in place, exactly as in König's operation, it is left uncovered by any other flap. After a short time the raw surface of the flap becomes covered by granulation tissue and the epidermis spreads over it. The local condition is now the following.

The tip of the nose is in normal position. The skin and bone flap D (Fig. 342) bridges over the defect created by the incision A, B (Fig. 340), and also the undivided skin at the root of the nose. Whenever flap D has become well healed, draw it slightly to one side; make a vertical median incision through the skin at the root of the nose above the defect. Elevate this skin on each side of the median incision, bring the edges up, and suture them to the vivified edges of the new nasal bridge (flap D, Fig. 342).

Von Mangold's Operation.—*Step* 1.—Make a small transverse incision across the middle line through the skin at the glabella. With a Kocher sound or blunt dissector burrow a tunnel under the skin, in the middle line down to the point of the nose.

Step 2.—Expose by incision the seventh or eighth costal cartilage. Excise a plate of cartilage, with its perichondrium, about 1¾ inches long, ⅜ inch wide, and ⅛ inch thick.

Step 3.—Push the excised plate of cartilage into the subcutaneous tunnel prepared on the nose. The side of the graft which has no perichondrium ought to be directed towards the skin. Close the little wound with sutures.

Step 4.—Make a small incision through the skin in the grooves to the outside of each ala of the nose. Through these incisions implant a thin strip of costal cartilage in each ala.

Von Mangold was able to form good nares, to correct saddle shape and to obtain a rectilinear nose, but it was necessary to lengthen and improve the shape of the organ at a second operation after an interval of five months.

Second Operation.—Through an inverted V-shaped incision (apex of V in middle line at root of nose, legs of V coming down on each side of the nose) detach the soft structures of the nose and with them the cartilaginous graft,

FIG. 343.—(*Marshall, Journ. A. M. A.*)

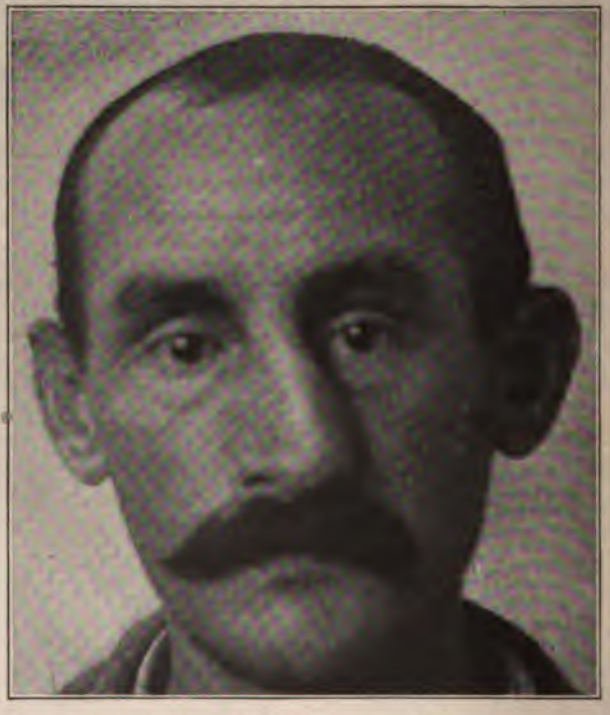


FIG. 344.—(*Marshall, Journ. A. M. A.*)

rom the subjacent structures. Carefully apply the upper end of the graft of cartilage into the angle between the glabella and the root of the nose. Suture the wounds.

External lateral deflections of the nose commonly the result of accidents or blows are often so disfiguring as to interfere seriously with the bearer's chances of earning his livelihood.

Marshall's Operation.—("Journ. A. M. A.," Jan. 18, 1913.)

Step 1.—With a tenotome puncture the skin over the nasal process of the superior maxilla where the elevation which makes the nasal prominence begins. Introduce a chisel about $\frac{1}{16}$ inch wide, through the puncture, and divide the

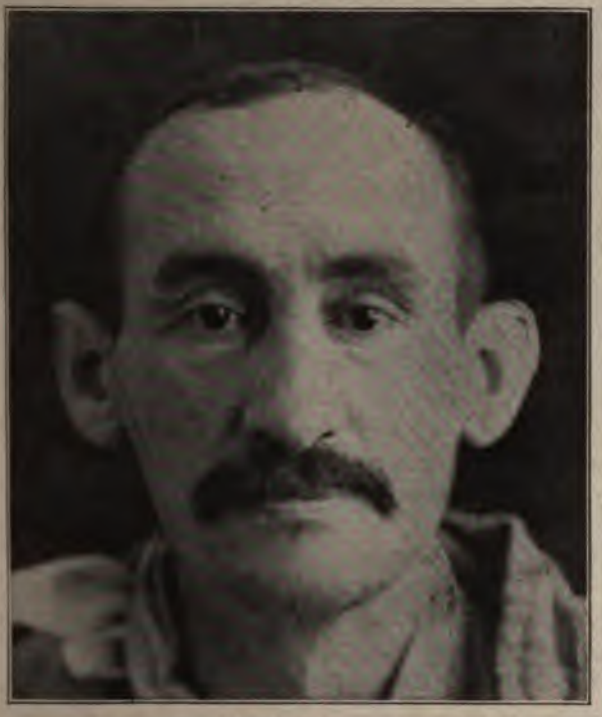


FIG. 345.—(*Marshall, Journ. A. M. A.*)

process *without* injuring the nasal mucosa (Fig. 343). The division of bone may be accomplished as widely as necessary without enlarging the skin incision. Apply pressure to the wound for purposes of hemostasis.

Step 2.—Do the same on the opposite side.

Step 3.—Introduce one blade of an Ashe septal forceps (better a heavier forceps with longer blades) into the nares, the other blade being outside, and complete by fracture the mobility of the nasal process along its entire line, for the upper part of the nasal process can usually be made mobile at the sutures along the lacrimal and the nasal bones on the corresponding side.

Step 4.—Do the same on the opposite side.

Step 5.—If there is a nasal obstruction through malposition of the septum, seize the septum with the same forceps and force it into correct position.

Step 6.—If the nose is not yet straight the defect probably lies at the suture between the frontal and upper extremities of the two nasal bones and both processes of the superior maxilla. Straighten this faulty angle "by a sharp stroke with the mallet at this point guarded by a rubber-covered lead plate, the force being directed downwards from the frontal bone, but towards the obtuse angle (that is, against the deflected side). Elevation can be assisted sometimes to advantage with a large urethral sound."

Step 7.—Dress the wounds with collodion. Occasionally Marshall inserts nasal splints for 24 hours. The nose ought to remain absolutely straight without being held in position. Do not use apparatus to hold the nose in position, such is uncomfortable and gets out of place to such a degree as to do more harm than good. Marshall instructs his patients to keep a moderate pressure on the originally deflected side for several days so as to obviate any tendency to recurrence of the deformity. Figs. 344 and 345 show a patient before and after operation.

CHAPTER XIX

TORTICOLLIS. WRY-NECK. CAPUT OBSTIPUM

There are several methods of operating on torticollis.

(*a*) Subcutaneous tenotomy of the sternal and clavicular portions of the sternomastoid. This operation is rarely performed, as its only advantage lies in the absence of scar, while its disadvantages are danger and incompleteness.

(*b*) Open section of the same structures, *plus* division of all bands of fibrous tissue which obstruct reduction of the deformity.

(*c*) Tendon lengthening.

(*d*) Excision of the degenerated sternomastoid (Mikulicz).

When the torticollis is of the spasmodic variety, the following methods have been advised:

(*e*) Division or excision of the spinal accessory nerve.

(*f*) Multiple myotomy (Kocher).

Open Tenotomy of Sternomastoid.—The favorite site for dividing the muscle is ½ to ¾ inch above the clavicle. The skin incision may be vertical, oblique, or transverse; probably the oblique is best. Beginning at the outer edge of the sternal attachment of the sternomastoid, make an incision 1 to 1½ inches in length, passing upwards and outwards to the middle of the anterior margin of the clavicular portion of the muscle. Retraction of the wound exposes both portions, which are easily isolated and divided without danger to other structures. Rotate the head firmly towards the sound side, keeping the shoulder of the affected side steady. This manœuvre puts all other contracted structures on the stretch. Divide all such, even down to beside the carotid packet of vessels. Attend carefully to hemostasis. Suture. Dress. Lorenz advises forcible overcorrection before the patient comes out of the anesthesia. The corrected or overcorrected position must be retained either by an extension apparatus or by means of a proper collar. After healing has taken place, massage,

exercise, and, for a time, the use of some orthopedic apparatus, such as Sayre's, are requisite.

Muscle Lengthening.—Thelwell Thomas ("Lancet," March 9, 1912) has obtained good results by muscle lengthening. It does away with long and tiresome after-treatment as he does not use any retentive apparatus. Make a transverse incision over the lower third of the sternomastoid. Expose the sternomastoid and isolate a sufficient segment of it. Estimate how much the affected muscle is shorter than its fellow. Split the affected muscle longitudinally for a distance equal to a little more than half the amount of the shortening. At the lower end of the vertical incision divide the anterior portion of the muscle transversely. At the upper end of the vertical incision divide the posterior portion of the muscle. Suture the ends of the muscle with chromicized catgut. Close the wound. It is often necessary to divide bands of deep fascia as well so as to obtain correction.

Myomectomy.—*Mikulicz's Operation.*—In severe cases of torticollis Mikulicz advises excision of the lower two-thirds of the sternomastoid, the upper one-third being preserved so as to avoid injury to the spinal accessory nerve.

Expose and divide the sternal and clavicular portions of the muscle as in open tenotomy. Seize the divided ends in forceps and pull the muscle downwards and through the skin-wound; as this is done, separate it from its surroundings by blunt and sharp dissection. Avoid injuring the external jugular vein. When two-thirds of the muscle is isolated, divide and remove it. Attend to hemostasis. Divide all cicatricial bands which can be felt. Close the wound. Apply dressings and pressure enough to obviate dead spaces. No subsequent orthopedic treatment is required.

Bruns in doing this operation removes only one-third of the muscle. The chief disadvantage of the operation is cosmetic, viz., the loss of the shapeliness of the neck. It should be reserved for severe or recurrent cases.

Division of the Spinal Accessory Nerve.—The spinal accessory nerve escapes from the skull through the jugular foramen. It runs obliquely downwards and backwards between the internal jugular vein and the digastric muscle, entering the sternomastoid muscle at a point about two inches below the mastoid process. The nerve pierces the muscle obliquely and proceeds across the posterior triangle of the neck to supply the trapezius.

The Operation.—Make an incision 2½ to 3 inches in length from the mastoid process downwards along the anterior border of the sternomastoid. Expose the anterior border of the muscle and divide the cervical fascia. Retract the muscle backwards. With the finger recognize the transverse process of the atlas, which is covered by the digastric muscle. The nerve, after passing between the bony process and the muscle, emerges at the lower edge of the latter and passes to the sternomastoid. Expose the nerve and either divide it or excise about ½ inch of it. Close the wound with sutures. Dress. The results of the operation are usually good; the danger is practically *nil.*

Nerve Section for Spasmodic Torticollis.—Division of the posterior primary divisions of the cervical nerves was first carried out by Gardner of Adelaide and Keen of Philadelphia in 1888. The operation is only suitable for very severe cases in which the disease has rendered life a burden. The object

of the operation is to paralyze all the muscles involved—*e.g.*, when the spasm turns the head to the right and extends it one should paralyze the *left* sternomastoid and trapezius and the right splenius capitis, trachelomastoid, superior and inferior oblique, rectus capitis, posticus major complexus and trapezius.

Robert Kennedy ("Brit. Med. Journ.," Oct. 3, 1908) has endeavored to simplify the exposure of the nerves, no easy matter at the best.

Step 1.—Make a vertical skin incision from ½ inch above the superior curved line downwards for 3 to 3½ inches midway between the external ear and the external occipital protuberance.

Step 2.—Define the posterior edge of the sternomastoid and deepen the incision behind the sternomastoid until the oblique fibres of the splenius capitis are exposed. Do not injure the spinal accessory nerve which may lie near the lower angle of the wound.

Step 3.—Define the upper border of the splenius capitis and divide that muscle in the line of the original incision. Divide the subjacent connective tissue exposing, above, the complexus whose fibres run longitudinally, and below, the trachelomastoid whose fibres run obliquely.

Define the outer edge of the complexus and the upper edge of the trachelomastoid.

The upper part of the wound is crossed by the occipital vessels. Deep down in a triangle formed by the occipital vessels and the two muscles lies the superior oblique muscle.

Step 4.—Follow the outer border of the complexus to its highest slip of origin (third cervical articular process). Detach this slip from the bone. Repeat this with the slip originating from the fourth articular process. Retract the trachelomastoid outwards. Fold the complexus inwards and so expose several nerves entering its deep surface. "The largest is the great occipital or internal branch of the posterior primary division of the second cervical and this pierces the complexus about the level of the lower edge of the lobe of the ear. Above the point at which the great occipital enters the complexus a slender branch can be seen entering the muscle and it can be traced back to the posterior primary division of the first cervical nerve. The latter, however, is best found by tracing out the slender branch of communication with the second posterior primary division which as a rule is present, passing upwards from the second division across the inferior oblique. It is very difficult to deal satisfactorily with the suboccipital nerve unless this communicating branch is early found and traced upwards at once to the first division which lies between the vertebral artery and the arch of the atlas, and of course, the operation is only imperfectly performed unless the first division is adequately dealt with. A short communicating branch leads from the second division down to the third division and is a safe way of reaching the latter. The fourth and fifth divisions can be easily found passing downwards and backwards close to the vertebræ. The nerves, from the second downwards, should be isolated to the point of separation into anterior and posterior primary divisions, but not further, and undue traction can quite easily pull the anterior primary division backwards and expose it to the danger of being damaged. The first nerve is sectioned just proximal to its branches, and the others near

their point of separation from the anterior primary division. In the great majority of cases the nerves once sectioned are excised from the point of section as far distally as can be reached."

Step 5.—The nerves having been exposed excise a segment of each. Do *not* stretch the nerves lest rupture of the roots occur and paralyze the anterior primary divisions. Resection of the nerves means total and permanent paralysis of the muscles involved. Kennedy suggests another method of operation in cases where the spasm, though very violent, has not been of long standing, and which refuses to yield to any known treatment short of operation. In such acute cases, *i.e.*, where the affection has lasted only a few months and there seems hope of cure, Kennedy gives the muscles rest by *dividing* and *immediately suturing* the spinal accessory of one side and the posterior primary divisions of the opposite side. "The result is that the violent spasm is immediately abolished, the affected muscles degenerate, and in the course of some weeks, after the nerves have regenerated, as indicated by the gradually returning sensation, the muscles begin to get built up again and shortly begin to resume their functions."

Multiple Myotomy.—*Kocher's Operation.*—Two incisions are necessary.

1. Make an incision 1¼ to 1½ inches in length along the anterior border of the sternomastoid, commencing opposite the angle of the jaw and passing upwards. Divide the platysma and if possible save the external jugular vein. Open the sheath of the sternomastoid along its anterior border. Introduce a blunt dissector under the muscle and divide it layer by layer. Attend to hemostasis. Close the wound with sutures. If desired, the spinal accessory nerve may be stretched or divided during this procedure.

2. The patient is turned on to his sound side. Beginning at the mastoid, make a transverse incision backwards. Through this divide the trapezius transversely and incise the splenius capitis and complexus muscles. Avoid injuring the great occipital nerve, which here traverses the complexus and trapezius. The inferior oblique muscle arises from the spinous process of the axis and is inserted in the transverse process of the atlas. Look for this muscle in the space between the atlas and axis and divide it. Attend to hemostasis. Close the wound.

Monod and Vanverts write as follows: "Section should be made of the muscles which participate in the spasm. It is necessary, by analysis, to determine prior to operation the muscles involved. One may be compelled to practise, according to the case, the following operations: division of sternomastoid and of the muscles of the nape of the neck on the opposite side (typical rotary tic); division of the sternomastoid and of the muscles of the nape of the neck on the same side (rotary tic with predominance of lateral deviation); division of sternomastoid and bilateral division of the muscles of the nape of the neck (rotary tic with much posterior extension)."

Remarks.—In some cases of torticollis no operation seems to be effectual; such are usually due to affections of the posterior nerve and muscle groups. Extirpation of the nerves involved has been advised, but this is a very complicated and, for most surgeons, inadvisable operation, and is not a glittering success.

In other cases any operation involving tenotomy is successful. When the muscle is greatly degenerated and adherent, Mikulicz's procedure is the best. In spasmodic varieties of torticollis section of the spinal accessory nerve is the operation of choice.

CHAPTER XX

EXCISION OF CERVICAL RIBS

Excision of Cervical Rib.—Cervical ribs vary much in size and may be unilateral or bilateral. They articulate with the seventh cervical vertebra and may end as a longer or shorter process lying among the tissues of the neck or their anterior end may be united to the first thoracic rib or to the sternum. Commonly no symptoms are produced, but sometimes the rib exercises pressure on the vessels or on the nerve trunks passing over it or on both. When these symptoms are severe and do not give way to conservative treatment, operation becomes necessary. Occasionally the rib itself is short but is continued forwards as a strong band of connective tissue and this band exercises pressure and gives rise to trouble. In such a case excision of the connective-tissue band is of course the proper treatment.

A. Operation from in front. *Step* 1.—*Incision.*—Numerous incisions have been devised: (*a*) Transverse, a finger's breadth above the clavicle reaching from the sternomastoid to the trapezius. (*b*) Oblique, along the anterior edge of the trapezius or a half inch in front of it. (*c*) Vertical over the most prominent part of the swelling caused by the rib. One incision is as good as another provided that free access is secured; sometimes it is necessary to combine two incisions so as to obtain room.

Step 2.—Divide the platysma and superficial fascia, doubly ligating and dividing the external jugular vein. Divide the deep fascia. Penetrate the underlying loose, vascular fatty tissue so as to expose the great vessels and the brachial plexus. Cautiously retract the vessels and nerves from over the cervical rib.

Step 3.—By blunt and sharp dissection separate from the rib the soft parts attached to it. Great care is necessary to avoid injuring the pleura which may be attached to the rib. The danger of pleural puncture has been much exaggerated. Subperiosteal resection of the rib is easier than extra-periosteal but one or more cases have been reported in which a secondary operation was required owing to reformation of the rib. At first expose and isolate a small median portion of the rib. From this as a starting-point follow the rib towards the spine and divide it with bone forceps, being careful to leave no sharp spicules protruding from the stump left attached to the spine. Follow the rib to its anterior attachments and divide them. Remove the rib. If complete excision is very difficult or risky it *may* occasionally be wise to resect merely that portion of the bone which is exercising injurious pressure on the vessels and nerves.

Step 4.—Attend to hemostasis. Close the wound with deep and superficial sutures.

B. Operation from behind. (Streissler's method.) From a point ¾ inch (2 cm.) lateral to the spinous processes of the vertebræ and one hand-breadth above the vertebra prominens make an incision downwards parallel to the spine to a point one hand-breadth below the vertebra prominens. Divide the trapezius, both the rhomboids, serratus posticus and splenius; separate the fibres of the complexus and semispinalis colli. Expose the transverse processes of the two lower cervical and two upper thoracic vertebræ. The articulation between the cervical rib and the transverse process of the seventh cervical vertebra with its strong ligaments is now in view. Remove the transverse process and so expose the thin neck of the rib. Pass a curved elevator around the neck of the rib and divide it, being careful not to injure the nerve roots immediately in front of it. Seize the rib with strong forceps and with sharp and blunt dissection free it from its connection as far forwards as possible. If the rib is too long or its anterior connections are too firm to permit complete and easy removal through the posterior wound, finish the removal through an anterior incision. The results obtained from excision of cervical ribs have usually been good. Streissler ("Ergebnisse der Chir. und Orthopedie," v, 280) gives an exhaustive account of cervical ribs.

CHAPTER XXI

EXCISION OF CERVICAL TUMORS

The various operations for the removal of cervical tumors, if at all extensive, should never be undertaken by a tyro in surgery. These operations are very dangerous in the hands of one who is not possessed of a good working knowledge of anatomy, especially of the anatomy of the living, and of wide surgical experience.

A good type of the operations under discussion is the removal of tuberculous glands. Ideally, when the disease is extensive, one should endeavor to remove all the cervical glands, and their lymphatic connections in one piece. This is, of course, impossible; but it is a good plan for the surgeon to try to approximate the ideal, even although he knows that his endeavors to do so will fall far short.

Greenwood Sutcliffe ("Practitioner," lxxxviii, 641) gives the following indications for the treatment of tuberculous cervical glands in children. When the disease has lasted not more than six months dietetic treatment with rest (in the open air) gives good results. Rest here means lying down and not running about. When the disease has lasted longer, there is usually caseation and operation is demanded. The author has found that suction hyperemia is often of great benefit in recent disease and that where caseation has taken place or even where abscess has formed, a small incision followed by suction hyperemia after the Klapp-Bier method, often renders excision unnecessary. When a reasonable trial of these simpler remedies fails, operation is proper.

What are the dangers of the operation?

1. **Hemorrhage.**—If care is taken, bleeding need cause little anxiety. The precautions taken to avoid air embolism will certainly have the effect of preventing much hemorrhage.

2. **Air Embolism.**—During inspiration the blood in the cervical veins is under negative pressure. If under these circumstances the vein is wounded, air is liable to be sucked into it and thus into the heart—a very fatal accident. Careful attendance to the principles of technic for cervical operations will obviate most of the danger.

(*a*) The wound through the skin and fascia should be large enough to give free access to every part to be operated upon.

(*b*) The wound should be kept moist, and if the slightest "hissing" sound be heard in the wound, the finger should press the tissue at a point nearer the heart than where the wounded vein is. The "hissing" signifies entrance of air. The digital pressure is meant to hinder the passage of the air towards the heart. At the same time as the finger pressure is applied, a spongeful of water must be squeezed into the wound. This effectually prevents more air getting in. The wound in the vessel must be caught by pressure forceps. J. B. Murphy places a small pack of gauze, with a thread attached to it to keep it from being lost, under the sternal attachment of the sternomastoid muscle. The pressure of the pack keeps the cervical veins full, prevents the danger of negative pressure, and makes the veins very visible. This expedient is of great value; the trifling increase in hemorrhage is of no importance. When "hissing" in the wound occurs and makes one suspect air embolism, remember that it may be due to the pleura being accidentally opened. The pleura extends an inch or more above the first rib.

(*c*) No more cutting should be done than is absolutely necessary. Blunt dissection is most meritorious.

(*d*) *Never* cut in the dark or without full knowledge of the safety of what is being divided.

(*e*) Bleeding points are at once caught by pressure forceps. If it is suspected that forcipressure kept up for a few minutes will be insufficient to stop the bleeding, the vessel should be secured by a fine ligature.

(*f*) In removing the glands no forcible tearing should be perpetrated. Veins are often very friable.

(*g*) Structures about to be cut ought *not* to be on tension. Tension empties veins and makes them look like bands of fibrous tissue.

(*h*) When in the *slightest* doubt as to the contents of a strand of tissue which must be severed, apply two forceps or two ligatures and cut between.

When, in spite of all precautions, air has been sucked into a vein, fill the cervical wound loosely with wet gauze; do not apply forceps to the vein; during the succeeding expirations forcibly compress the chest; do *not* lower the head and shoulders of the patient.

3. When operating down low in the neck on the left side, **avoid injuring the thoracic duct.** Such injury is not uncommon. If noticed at the time, one sees a little clear fluid escaping. Compression sutures in the vicinity of the injured duct *plus* gauze packing usually leads to recovery, but fluid escapes, in spite of treatment, for about two weeks, and there is great emaciation. The injury generally heals in about three weeks or less. P. Lecène thoroughly discusses this accident ("Revue de Chir.," Dec., 1904).

Edward Harrison (Brit. J. of Surg., 1917, IV, 304) reviewing the treatment of wounds of the duct comes to the following conclusions:

1. Suture is the best treatment. Suitable in splits and tears. (Five cases all successful.) When there is complete division of duct, end-to-end suture is best.

2. Implantation into any convenient vein. In one case the divided duct was put into the central segment of the external jugular vein which was divided for the purpose and fixed by sutures.

3. Occlusion of duct by ligature or forcipressure. This gave many good results, possibly because in 18 out of 40 cases there were two terminal branches of the duct and perhaps only one of these was occluded. Collateral circulation may aid in recovery after ligation.

4. Tamponade is a *dernier ressort.*

4. Injury to Important Nerves.—The danger of injuring important nerves in the neck is by no means great. The vagus is well protected, lying in the carotid sheath. If care be taken, the spinal accessory nerve can usually be recognized and often preserved; its preservation is of much greater importance in the young than in the mature. Injury to the phrenic and the recurrent laryngeal nerves is extremely rare. Injury to the cervical sympathetic system seems to produce no ill results.

The Operation.—In slight cases where the glands are neither numerous nor adherent the operation is extremely simple. An incision is made over the swelling and through this the tumors are easily shelled out. The method of operating about to be described is for extensive and complicated disease.

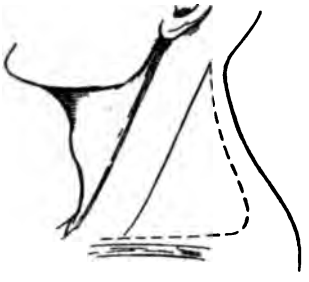


FIG. 346.

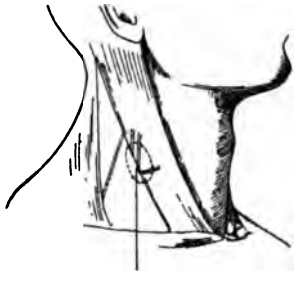


FIG. 347.—Superficial cervical nerves.

The patient lies on his back with the shoulders supported and the head turned towards the side. The scalp should be covered by a well-fitted gauze or rubber cap, to keep the hair out of the way. An oblique incision is made along the sternomastoid muscle from the mastoid process to near the sternoclavicular articulation. The external jugular vein is exposed and divided between two ligatures. The skin anterior and posterior to the incision is dissected from the subjacent tissues and retracted. If necessary, a second cut may be made parallel to and near the clavicle, from the lower end of the oblique incision outwards. Another incision, and one which leaves little noticeable scar, follows the margin of the vertical hair line of the back of the neck; to this cut is joined one following the clavicle forwards (Fig. 346). Expose the sternomastoid and free it from its surroundings throughout its whole length. Notice the point

of emergence of the superficial cervical nerves at the posterior edge of the muscle; the nerves are not small, and here the muscle is more firmly attached to its surroundings than elsewhere, hence this point constitutes an anatomic landmark (Fig. 347). One-half inch above this landmark the spinal accessory nerve emerges from the sternomastoid muscle and is easily found. The nerve enters the muscle about two inches below the tip of the mastoid process, after passing over the prominent transverse process of the atlas. In cases of tuberculosis it is commonly easy to trace the nerve in its course to the trapezius and to separate it from the diseased structures. In the young it is important to preserve the nerve, because Fenger has shown that its division leads to drooping of the shoulder and to scoliosis.

The packet of fascia which contains the carotid artery, internal jugular vein, and the vagus must now be exposed. Once exposed, the protection of these extremely important structures becomes more or less easy. Up to this time no attempt has been made to remove diseased tissues. The disease is now attacked. Beginning near the lower end of the wound and by the side of the carotid packet, the removal of the diseased glands with the gland-bearing fascia is generally a comparatively easy matter and can be carried out systematically. If the important anatomical structures are not exposed and protected at an early stage in the operation, systematic, thorough removal of the glands is very difficult and dangerous. The diseased structures having been removed and all hemorrhage stopped, carefully suture the wound in the cervical fascia, preferably with catgut. Suture of the fascia and platysma most notably removes tension from the skin-wound. If the fascia is not well united, the skin-wound is liable to stretch and give rise to a wide, ugly scar. Provide drainage at the lower angle of the wound. Close the skin-wound neatly, using intradermic sutures or ordinary sutures, preferably of horse-hair. Horse-hair sutures, being elastic, leave less scar than sutures of any other material. After operations on the neck, very extensive dressings are required as small dressings are difficult to keep in place.

In the course of any operation for the removal of tuberculous glands some of them may be ruptured and from them there escapes caseous material. Such extravasated matter must be carefully wiped away, and it is good practice to scrape the remnants of the caseated material from the ruptured gland, subsequently mopping the part scraped with liquid carbolic acid, followed by the application of alcohol to neutralize the carbolic. When glands are so firmly united to the great vessels of the neck that their removal is very risky, it is proper to remove as much of the gland as possible and sterilize the remainder with liquid carbolic, afterwards neutralizing with alcohol.

Subcutaneous Removal of Tuberculous Glands in the Neck and Submaxillary Regions (Dollinger's Operation).—The operator sits behind the head of the patient and wears an electric headlight. An assistant holds the patient's head free and moves it to suit the convenience of the operator. Beginning near the external auditory meatus, make an incision, 2½ to 3 inches in length, downwards and backwards, parallel to and about ⅓ inch from the margin of the hair. Through this incision packets of glands in almost all the cervical region may be reached and removed by blunt dissection, the surgeon

undermining the skin to a point below the packet to be removed and removing the glands from below upwards. Nerves and vessels must be pushed aside. When the glands are seized with forceps, they often tear or collapse, especially if they are caseated. This accident, according to Dollinger, does no harm, provided the débris is promptly washed away. Cases in which peri-adenitis has caused the formation of many firm adhesions are unsuitable for this operation. After removal of the glands the whole wound must be reviewed, cleaned, drained, and sutured. The hemorrhage is remarkably slight.

The location of particular groups or packets of glands is as follows: I. The retroauricular and subauricular glands lie next to the incision and are easily removed.

II. The preauricular glands lie on the parotid beneath the masseteric fascia which they penetrate and so reach the subcutaneous tissues. To reach them pass under the external auditory meatus. The facial nerve is not in danger.

III. The glands under the head of the sternomastoid lie posterior to the accessory nerve, which must be carefully preserved.

Glands also lie in front of and beneath the nerve and must be removed with great care. One reaches these glands from the wound by dissecting under the posterior edge of the sternomastoid.

IV. Glands in the vicinity of the lower end of the parotid gland and of the posterior facial vein are reached by burrowing between the skin and the sternomastoid. When the disease is of long standing, the posterior facial vein is often obliterated. Preserve the external jugular vein and the great auricular nerves.

V. Glands about the submaxillary salivary glands. These are usually three in number and lie between the salivary gland and the lower jaw. One next burrows between the skin and the sternomastoid to the group of glands anterior of the muscle, and illuminating the wound with the headlight, opens their fascial covering and removes them bluntly.

VI. The submental glands, two in number, lie between the anterior bellies of the digastric. These are best removed through a small incision directly over them.

VII. Glands in the lateral triangle of the neck number about 50. The upper ones can be easily reached through the primary incision. The lower ones lying in loose connective tissue are easily pushed upwards and extirpated. Look out for and preserve the branch of the spinal accessory going to the trapezius, the cervical and the brachial plexus. These structures are separated from the glands by a layer of cervical fascia. The external jugular vein is often obliterated.

VIII. The deep cervical glands lie along the great vessels under the sternomastoid, and can be reached by undermining the muscle. If the glands are firmly united to the vessels, pull them to the surface with a sharp hook and carefully dissect them free. Remember that the traction empties the internal jugular vein and makes it look like an innocent band of tissue.

This proceeding seems to the author very hazardous. Dollinger's operation seems to be excessively difficult, and may easily be very incomplete, but that surgeon has performed it in very many cases, and with excellent results.

[Dollinger's description of his operation appears in the "Proceedings of the German Surgical Society," 1903.]

When the disease for which operation is required is malignant, almost everything holds good which has been said regarding the excision of tuberculous glands, but the work is more complicated and difficult. That malignant disease should be excised as thoroughly as possible is as true in the neck as elsewhere, but thoroughness is more difficult to attain in this region. The incision made must vary according to circumstances. It may be obliquely vertical, transverse, or a horseshoe-shaped flap with its pedicle upwards or downwards may be dissected from over the tumor. When the growth is exposed, it must be separated from its surroundings. In doing this it is usually wise to attend to the most dangerous part first. Thus, when feasible, the surgeon should begin the enucleation at the point nearest the large vessels, so that in case of accident or difficulty these may be under control. If the carotid artery or the internal jugular vein passes into or becomes inseparably united to the tumor, it is well to know the trouble early in the operation so that one may intelligently make up his mind as to the propriety of braving the dangers of a completed operation or the advisability of closing the wound before it is too late to recede.

FIG. 348.—Crile's clamp.

The carotid artery lies deeper than the vein and is rarely involved in the disease. The vein is often infiltrated or surrounded by the tumor and requires ligation or removal, which is not particularly dangerous. Ligation of the common carotid has a mortality of about 26 per cent. (from cerebral softening principally). See p. 839. In operations for malignant disease Crile applies his clamp (Fig. 348) to the artery and thus temporarily controls it. Some surgeons throw a soft temporary ligature around the artery, which serves the same purpose as Crile's clamp but does not do so in quite as elegant a fashion. Temporary control of the carotid is of great value in operations for malignant neoplasms.

If it seems probable that the tumor may be dissected free from the vessels, it is often proper to lay a ligature loosely in position around the internal jugular vein (to the cardiac side of the growth) so that, should air embolism be seriously threatened during the later stages of the operation, an assistant can quickly tighten the thread and avert danger.

Note.—In connection with severe surgical operations on the neck it should be distinctly understood that section of the vagus nerve is not necessarily fatal. Giordano (quoted in "Annals of Surg.," June, 1894) finds that after maltreatment of the nerve in surgical cases the mortality is not higher than 45 per cent., while in resection it is 75 per cent. Crile ("Problems Relative to Surgical Operations," 1901) has made numerous experiments on the vagus and reports a number of cases in which the vagus of one side was excised without ill

effect. Before operations in which the vagus may be irritated or divided he finds it wise to administer 1/100 grain of atropin in order to prevent any cardiac or respiratory inhibition.

Hydrocele of the Neck; Cystic Lymphangioma.—A hydrocele of the neck consists of a monolocular or multilocular cyst which may extend into the anterior mediastinum or deep down among the large vessels of the neck. The disease is congenital. Of course, the ideal treatment is extirpation, but this is rarely proper because of its difficulty and danger. If extirpation is decided on, the operation ought to be delayed until the end of the first year of life (Arrou). The most common operative treatment consists in evacuation by trocar and cannula, followed by irrigation with a 2 per cent. solution of carbolic acid, or by injection of tincture of iodine diluted with water. This simple treatment often gives excellent results; it is liable to fail when there are many compartments or loculi in the cyst. When evacuation and injection fail or are inappropriate, marsupialization affords a means of treatment which is thorough and is safer than extirpation. Marsupialization consists in incising the cyst; suturing the edges of the wound in the cyst to the skin; opening the subsidiary cyst cavities; evacuating all the contents and providing for drainage by means of a gauze tampon. In the course of the operation part of the cyst-wall may be removed and the interior of the cavity may be swabbed first with liquid carbolic acid and then with alcohol to neutralize the carbolic.

Congenital cervical fistulæ require radical treatment when they give rise to much inflammation or to cystic tumors; esthetic considerations may call for their removal. Occasionally the fistulæ are shallow and their extirpation is then easy. Usually they are complete, reaching from the neighborhood of the tonsil (Rosenmüller's fossa behind the tonsil), passing under the digastric muscles to penetrate the cervical fascia and the skin in almost any location between the sternomastoid muscles. Such fistulæ must be *completely* excised, otherwise recurrence is liable to take place. The skin-incision must be extensive and the cord-like fistulous track followed (preferably without being opened), under guidance of the eye, up to its pharyngeal termination. The dissection is not one for the tyro in surgery to attempt. The removal of the pharyngeal end and closure of the pharyngeal wound are most difficult, but this difficulty has been evaded in a most ingenious manner by Fritz König. After the fistula has been mobilized to a point above the digastric muscle, König separates it still further from its surroundings by blunt dissection until the pharyngeal mucous membrane is nearly reached; then he opens the mouth with a Whitehead speculum, passes a stout probe with an eye on the proximal end through the wound, and makes its point appear elevating the mucous membrane in front of the lower margin of the tonsil. An incision made through the mouth over the end of the probe permits the latter to be pulled through, and with it a thread of silk. The end of the fistula, after being tied to the thread, is easily pulled into the mouth, fastened by a couple of stitches to the wound in the mucosa, and its free end cut away. The external wound is now closed. Instead of a long fistula leading from the pharynx to the skin, there is a short, harmless fistula leading from the back to the front of the tonsil. This simple "dodge" of König's is one of great value.

Median cervical fistulæ are different from those alluded to above; they are the result of non-obliteration of the thyroglossal duct. The thyroglossal duct leads from the foramen cæcum on the tongue through the root of that organ down to a low point in the neck. On its way down the duct either passes through or is closely connected with the body of the hyoid bone. Excision of a patent or inflamed duct below the hyoid is easy; above that bone, it may be difficult or easy, generally the former. If the duct passes through the hyoid, the portion enclosed in the bone must be thoroughly removed even if it is necessary to excise a portion of the bone itself. Occasionally that part of the duct which traverses the tongue gives rise to a tumor consisting of tissue very like that of the thyroid gland. Cysts arising from distention of the duct above the hyoid may give rise to ranula-like tumors. In treatment of ranula it is well to bear this fact in mind. A stubborn and obscure recurrent phlegmonous inflammation in the submental region may be due to an unsuspected remnant of the thyroglossal duct.

Lingual thyroid may occasionally be easily shelled out of the tongue or extensive operations may be necessary.

W. G. Spencer (Royal Soc. Med. Surg. Sect., 1914, 163) draws attention strongly to the fact that a lingual thyroid not infrequently is the only active thyroid present in the individual and that as a consequence hypothyroidism must result should that tissue be removed. He writes "from the standpoint of a clinical examination, then, it is of primary importance to recognize the presence of the isthmus of the thyroid gland or the reverse. When the isthmus is absent, so that the tracheal rings from the cricoid cartilage downwards can be felt, it should be assumed that the patient's actively secreting thyroid may have been developed in the course of the thyreoglossal tract, and although there may be a fullness on either side of the trachea suggesting the existence of lateral lobes, yet these may be parathyroids destitute of any true thyroid function."

Spencer thinks that when the lingual thyroid has caused so much swelling at the base of the tongue as to impair breathing or has ulcerated and hemorrhage has followed, then the removal of a small wedge and suture, or a limited application of the cautery is the proper treatment. If it is necessary to excise the lingual thyroid probably Matti's operation will be found suitable (Archiv f. Klin. Chir., ciii, 248).

Matti's Operation.—Preliminary tracheotomy is advantageous.

Step 1.—Make a curved collar incision through the skin and platysma at the upper margin of the hyoid bone. The length of the incision depends on the size of the tumor but in any event it ought to be long enough to permit preliminary ligation of one or both lingual arteries beside the great horn of the hyoid. Reflect the flap of skin and platysma upwards as far as possible.

Step 2.—Isolate and divide the middle of the body of the hyoid bone. Split the raphe between the mylohyoid, geniohyoid and genioglossus muscles and retract these muscles laterally along with the two segments of the hyoid bone.

Step 3.—Remove the tumor after dividing its firm attachments to the hyoid bone. This may sometimes be accomplished without penetrating the lingual mucosa. The operation may be much facilitated if an assistant

presses upon the lingual surface of the tumor with his fingers in the patient's mouth.

Step 4.—If the mouth has been penetrated, the wounded mucosa must be sutured. The wound must be packed or drained, the muscles sutured correctly and the skin closed except where the drain protrudes.

CHAPTER XXII

EXCISION OF THE CERVICAL SYMPATHETIC

Jonnesco describes the total excision of the cervical sympathetic very nearly as follows:

Step 1.—*Cutaneous incision:* Make a cut from behind the mastoid process downwards along the posterior border of the sternomastoid to a point a little below the clavicle. The external jugular vein is divided between two ligatures.

Step 2.—*Separation of the posterior border of the sternomastoid:* To avoid section of the external branch of the spinal accessory nerve and the difficulties often met in freeing the posterior border of the muscle in the upper part of the wound, make an incision along the muscle parallel and close to the posterior margin. Separate the fibres of the muscle and operate through this elongated button-hole.

Step 3.—*Search for and isolation of the sympathetic nerve:* Retract the muscle and with it the packet of cervical vessels and nerves (carotid artery, internal jugular vein, vagus nerve) inwards and upwards. Two blunt hooks or one wide blunt retractor are useful for this purpose. Look for the nerve in the middle of the wound, either on the posterior surface of the sheath of the vascular packet with which the nerve may have been retracted inwards or on the vertebral column, where it lies in a special aponeurotic sheath. The nerve is easily found. It is impossible to confound it with the vagus, the descending branch of the hypoglossal (descendens noni), or the phrenic. To dispel all doubt as to identity follow the nerve upwards and see the superior ganglion (Fig. 349).

Step 4.—*Isolation and resection of the superior ganglion:* Follow the nerve-trunk upwards to the ganglion and isolate the latter from below upwards by blunt dissection with a director. Divide its afferent and efferent fibres with blunt-pointed curved scissors. When the upper end of the ganglion is isolated, divide or tear away the trunk which leads from it towards the skull (Fig. 350).

Step 5.—*Liberation of the inferior thyroid artery:* This artery is surrounded by a dense and often adherent nervous plexus consisting of the sympathetic trunk and its branches. The nerve often is swollen at this point, forming the middle cervical ganglion. Put tension on the nerve-trunk already isolated and follow it downwards. Elevate the nerve and the inferior thyroid artery together and separate them by careful blunt dissection (Fig. 351).

Step 6.—*Isolation and resection of the inferior ganglion:* This is the most difficult step in the operation, as the ganglion lies deeply imbedded in a special lodge at the base of the neck or even in the thorax, behind the clavicle, against the neck and head of the first rib, between the scalenus anticus and longus

colli muscles and just above the pleura. Using the trunk of the nerve as a guide, penetrate to the ganglion, which lies sometimes internal to, and sometimes (though rarely) external to, the vertebral artery. The ganglion is

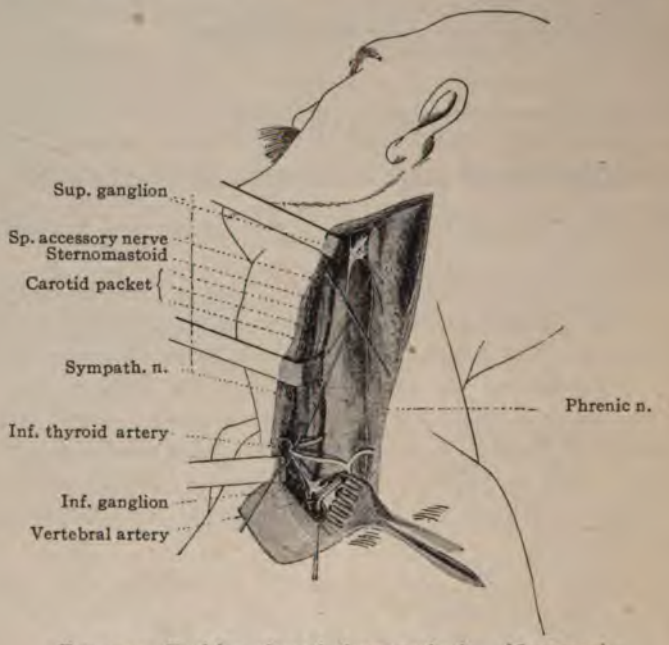


FIG. 349.—Excision of cervical sympathetic. (*Jonnesco.*)

adherent to the artery and enlaces it in a meshwork of its efferent and afferent fibres (Fig. 351). With appropriate retractors retract the scalenus anticus, thyroid axis, and the vertebral artery and vein, downwards and outwards;

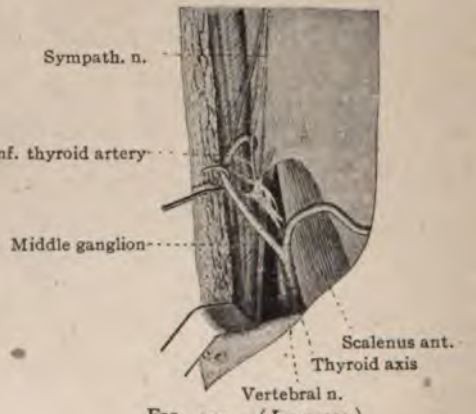


FIG. 350.—(*Jonnesco.*)

retract inwards and forwards the sternomastoid muscle and the carotid sheath with its contents. Divide, with a grooved director, the cellular and aponeurotic tissues covering the vessels and the ganglion. Seize the ganglion with for-

ceps and isolate it successively from the vertebral artery externally and from the rib and spine internally. Isolate and divide the afferent and efferent fibres, and remove the ganglion.

The dangers which may be encountered are:

1. Injury to the vertebral artery and vein.
2. Injury to the first intercostal artery or its cervical branch.
3. Injury to the subclavian artery, especially on the left side.
4. Injury to the pleura.
5. Friability of the ganglion, rendering *morcellement* necessary.
6. Intimate union of the inferior cervical and first thoracic ganglia into one mass, from which a portion must be removed.
7. Injury to the retroclavicular venous plexus. This accident will be rare if the trunk of the nerve is followed closely.

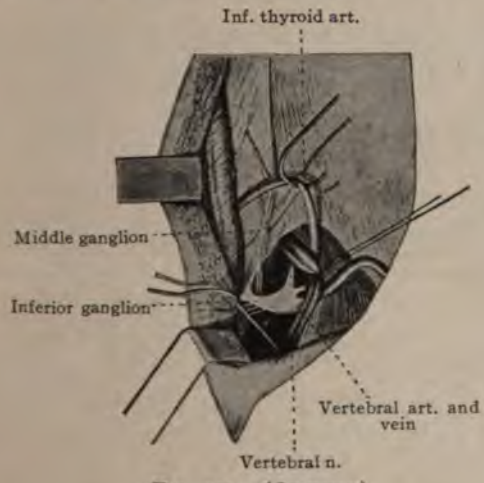


FIG. 351.—(*Jonnesco.*)

Step 7.—Suture of the Wound.—Close the wound completely with buried and superficial catgut sutures. The superficial stitches ought to be introduced in the intradermic fashion so as to leave little scar. There should be no drainage. Apply dressings.

Immediately after operation on one side the corresponding pupil dilates, the face flushes, eye waters, and nose secretes abundantly. These phenomena, except the pupillary dilatation, are very transitory. The pulse falls below normal for a few days; after partial resection of the sympathetic it is accelerated. The operation seems to have no ill effects.

After the patient has recovered from the operation on one side the other side should be attacked in the same manner.

Jonnesco ("German Surg. Congress," 1906) has performed cervical sympathectomy in 159 cases, in 141 of these the three ganglia were removed with or without the first thoracic ganglion. In all but two cases the operation was bilateral. There were no deaths and no secondary trophic troubles. The therapeutic results were:

1. Twenty-five cases of exophthalmic goitre (two subtotal resections;

twelve complete; eleven cervico-thoracic resections). In every case the disease was primary Basedow's disease, either complete or incomplete, often of serious degree. All the patients recovered, every symptom disappearing. He recommends strongly the complete operation with or without removal of the first thoracic ganglion.

2. *Glaucoma.*—Eighty-eight cases of superior sympathectomy have been collected showing sixty-one cured or improved, twenty-two unimproved, five aggravated.

3. *Epilepsy.*—One hundred and seventeen cases with but twelve definite cures.

4. *Trigeminal Neuralgia.*—In one case resection of the superior ganglion resulted in recovery which has lasted four years, in another case for six months.

De Souza has had similar experiences in Basedow's disease and in facial neuralgia.

Farquhar Curtis finds that the mortality after sympathectomy for Basedow's disease is very high and the ultimate results in the survivors fair. ("Annals Surg.," March, 1906.) Alexander of Liverpool at one time performed sympathectomy frequently for epilepsy but gave it up. The operation is still *sub judice.* *

Periarterial Sympathectomy.—R. Leriche (La Pr. Med., Sept. 10, 1917 and May 15, 1920) recommends periarterial sympathectomy in causalgia and certain trophic troubles. He believes that most if not all rebellious causalgias are due to disturbances of the sympathetic system, that the burning pains following certain nerve wounds is not due to the injury to the nerve itself, but to lesions of the neighboring perivascular sympathetic or of the intra-nervous sympathetics, *e.g.*, of the sympathetic fibres brought into the median nerve by its special artery. This explains the fact noted by Marie, Meige and Mme. Benisty, that the pain after nerve wounds is a reaction proper to nerves provided with a special artery or which are near a large artery.

The sympathetic plays a very great part in the production of the true Babinski—Froment reflex contractures in which vaso-motor and thermic phenomena are associated with motor disturbances of the muscles. In cases of this kind Leriche has seen motor troubles disappear almost completely after sympathectomy. The day after operation mobility has returned notably in hands up till then so contracted that the fingers were flexed into the palm or stiffly extended dorsally. Sympathectomy on the brachial artery has apparently cured ulnar claw hand (griffe cubital).

The results of Leriche's observations are:—(1) In causalgia periarterial sympathectomy sometimes cures, almost always improves (2) trophic ulcerations. Five patients submitted to operation. All cured. (3) Blue oedema of the extremities. Three submitted to operation. Cured; much improved 1; some improvement 1. (4) Reflex disturbances 18 operations. Practically cured 3, (disappearance of vaso-motor disturbances and of contractures). More or less improved (some almost cured) 10; improved but with later incomplete recurrence 2; failures 2.

*Leriche [Bul. Soc. Chir. Paris 21, Dec., 1920] has relieved or cured (1) progressive facial hematrophy, (2) post-herpetic hemicrania, and (3) permanent lagophthalmos in facial palsy by means of excision of the superior cervical sympathetic ganglion.

ceps and isolate it successively from the vertebral artery externally and from the rib and spine internally. Isolate and divide the afferent and efferent fibres, and remove the ganglion.

The dangers which may be encountered are:

1. Injury to the vertebral artery and vein.
2. Injury to the first intercostal artery or its cervical branch.
3. Injury to the subclavian artery, especially on the left side.
4. Injury to the pleura.
5. Friability of the ganglion, rendering *morcellement* necessary.
6. Intimate union of the inferior cervical and first thoracic ganglia into one mass, from which a portion must be removed.
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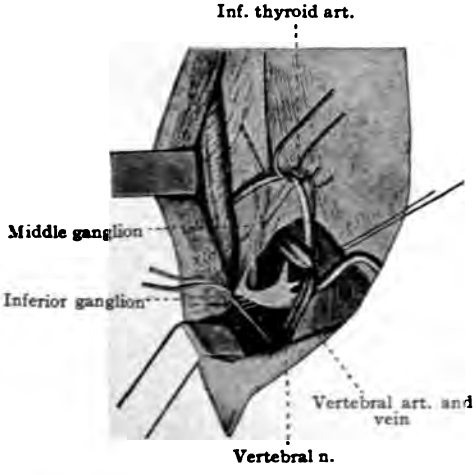

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1. Twenty-five cases of exophthalmic goitre two subtotal resections;

CHAPTER XXIII

RETROPHARYNGEAL ABSCESS AND TUMORS

There are two methods of opening retropharyngeal abscess, viz., through the mouth and through the neck.

1. **Opening the Abscess through the Mouth.**—No anesthetic, not even cocaine, is permissible. If the pharynx and larynx were anesthetized, there would be increased danger from inspiration of discharges. A knife, the edge of which is protected with cotton or adhesive plaster to within one inch of the point, is guided on the finger of the left hand through the mouth to the posterior wall of the pharynx. An incision is made into the abscess at its most prominent point. The knife is at once withdrawn. If the patient is a child, the operation should be performed in the Rose's position—*i.e.*, with hanging head, and in any case as soon as pus begins to flow the head should be lowered and the body elevated. The after-treatment consists in the use of antiseptic gargles and sprays and in keeping the wound open by daily probing, if this is necessary.

2. **Drainage through the Neck.**—*Chiene's Operation.*—Make an incision two inches in length along the posterior margin of the sternomastoid, beginning at the apex of the mastoid process and running downwards. After division of the deep fascia one can by blunt dissection reach the anterior surface of the bodies of the cervical vertebræ where the abscess is situated. The skin and fascia having been incised as above, the pus may be reached and evacuated by Hilton's method. This is a very safe and easy procedure.

Remarks.—Retropharyngeal abscess may be acute or chronic. It is only for the former that operation through the mouth is suitable. On purely theoretical grounds the operation through the mouth must be condemned for the following reasons: (*a*) When the pus begins to flow there is danger of asphyxiation. (*b*) No dressings can be applied to soak up discharges and keep out dirt. (*c*) There is grave danger of septic pneumonia and of infection to the gastrointestinal canal. (*d*) If the case is one of tuberculous abscess, secondary infection is certain. *Practically* it has been found that by using Rose's position or by inverting the patient during the first flow of pus the danger of asphyxiation is averted, and that in acute cases rapid recovery does ensue. An advantage is claimed for this operation, viz., that an anesthetic is not necessary, but certainly in case of need the external operation can be done under a local anesthetic.

The advantages of the external route are: (*a*) The possibility of careful removal of diseased foci, *e.g.*, diseased bone, etc.; (*b*) the possibility of treating the abscess antiseptically and providing for permanent draining; (*c*) the possibility of avoiding secondary infection; (*d*) the avoidance of the danger of drowning the patient in his own pus.

The principal disadvantage is the scar which must be left, but as a rule it is not very noticeable.

Retropharyngeal Tumors.—I. The tumor is not adherent to the spinal column, but is movable. Perform tracheotomy. Tampon the larynx or trachea. Place the patient in Rose's position. Introduce a mouth-gag and open the mouth. Pierce the tongue with a needle and pull through a stout thread which serves as a handle to manipulate the tongue. Make an incision through the mucous membrane of the posterior pharyngeal wall and expose the tumor freely. Busch has shown that the tumor lies loosely imbedded in the retropharyngeal tissues and can be shelled out. Generally blunt dissection with closed curved scissors will result in easy removal of the growth. Clean the pharyngeal cavity and the wound with a non-poisonous antiseptic.

If necessary to obtain more room, the soft palate may be divided longitudinally. This wound must be closed by suture as soon as the tumor is removed.

II. The tumor is so extensive that removal through the mouth is impossible. The pharynx must be opened from the neck.

FIG. 352.—Exposure of pharynx from the neck.

Step 1.—Make a **U**-shaped incision beginning in front of the masseter and ending at the tip of the mastoid process. The lowest part of the **U** reaches below the level of the hyoid bone. Doubly ligate and divide the external jugular vein. Reflect upwards the skin-flap outlined by the incision (Fig. 352).

Step 2.—Divide the cervical fascia along the anterior margin of the sternomastoid. Expose the external carotid artery. This artery, partly covered by the internal jugular vein, should be sought on the line of the anterior margin of the sternomastoid between a point on a level with the hyoid and one on a level with the upper edge of the thyroid cartilage. Before tying the vessel expose at least one of its branches. This precaution is recommended because the internal has occasionally been mistaken for the external carotid.

Step 3.—Doubly ligate the artery and divide it between the ligatures. Expose as thoroughly as possible such part of the tumor as may present between the inferior maxilla and the mastoid. If it is feasible to remove the tumor through this space, do so; otherwise proceed to the next step.

Step 4.—Cut through the soft structures covering the inferior edge of the horizontal ramus of the lower jaw at a point just in front of the masseter muscle. Through this incision with an elevator separate the periosteum from the bone sufficiently to allow of subperiosteal section of the bone. With finger-saw, forceps, Gigli's wire or the chain saw divide the bone. Dislocate the temporomaxillary joint and turn the ascending ramus of the jaw upwards together with the soft parts covering it. This gives very free access to the pharyngeal wall.

Step 5.—Isolate the tumor by blunt dissection if possible. *Do not open* the pharyngeal cavity before it is absolutely necessary to do so. Remove the growth.

Step 6.—Pack the cavity with iodoform gauze. Replace the dislocated portion of the lower jaw and wire it in position. Close most of the wound in the soft parts by interrupted silkworm-gut sutures, leaving an opening through which the gauze pack protrudes. Dress.

In one case the writer was surprised to find that he was able to shell out in the above manner a large tumor affecting the right side and roof of the pharynx, without tearing or dividing the pharyngeal mucous membrane.

As a preliminary to the operation tracheotomy may or may not be performed. If the growth, either from size or location, does *not* interfere with respiration; if the surgeon ligates the external carotid artery near its origin and does not open the pharynx until the tumor is almost entirely separated and hemostasis has been secured, then a preliminary tracheotomy appears superfluous.

CHAPTER XXIV

ŒSOPHAGUS

Œsophagotomy.—The œsophagus may be opened either in the neck or in the posterior mediastinum. The latter operation is discussed elsewhere.

Cervical œsophagotomy is performed for the removal of foreign bodies, the treatment of stricture, the excision of small, sharply defined tumors, or as a step in the operation of œsophagostomy. Place the patient on the table with shoulders slightly elevated and the face turned towards the right. Beginning at the level of the thyroid cartilage, make an incision downwards for about three inches along the anterior margin of the left sternomastoid muscle. Divide the platysma, superficial and deep fasciæ. The omohyoid may be divided or retracted according to convenience. Retract the thyroid gland and trachea towards the right. Notice, in the wound, the common sheath containing the carotid, internal jugular, and vagus. Retract these structures to the left. The œsophagus will now be exposed. If a foreign body is present, fix the œsophagus with small volsellum forceps and make a longitudinal cut into it over the foreign body. If necessary, enlarge the wound with a probe-pointed bistoury or with scissors. Gently extract the foreign body. This frequently requires much patience. The incision through the œsophagus should be made on the side, as the recurrent laryngeal lies in the groove between it and the trachea.

When no foreign body is present distending the œsophagus, pass an œsophageal bougie through the mouth and cut down upon it when incising the gullet wall.

v. Hæcker (Muenchener med. Woch., Oct. 15, 1907) reports the case of a pregnant woman who swallowed her plate with artificial teeth. This irregular body became impacted where the œsophagus crosses the left bronchus. Attempts at removal by the œsophagoscope having failed, Friedrich opened the œsophagus just above the upper thoracic aperture and removed the plate after dividing it with cutting forceps. The wound was packed around an œsophageal catheter through which food was administered. Soon an œsophageal-bronchial fistula formed and gangrene developed. Gastrostomy was now performed and for three months the patient was nourished through the gastric fistula. After this time the broncho-œsophageal fistula closed and the patient recovered perfectly.

Bodies impacted low down in the œsophagus have been extracted through gastrotomy wound in twenty out of twenty-four cases (v. Hæcker). A ugie passed through the mouth gives great assistance in the work.

Foreign bodies may be removed from the lower œsophagus through the mach. M. H. Richardson successfully performed gastrotomy, explored the ver œsophagus and removed a plate containing four teeth which had been ged there for eleven months. A peach stone was arrested 6 or 7 inches above cardiac orifice; the usual measures failed to dislodge it; W. T. Bull per- med gastrotomy, passed a small bougie, with a loop at its point, from the mach to the mouth, pulled a stout thread through the œsophagus with the ugie; tied a sponge to the lower end of the thread and pulled the sponge rough the œsophagus and out of the mouth. The sponge swept away the eign body.

Through the œsophageal wound one may divide or forcibly dilate a stricture even remove a small tumor. For such purposes, however, the operation will but little used, as strictures are generally more suitably treated by other ans, and tumors eradicable by the above operation must be of great rarity.

Closure of the Wound.—Close the œsophageal wound by a row of sutures of e catgut not involving the mucosa. Lessen the size of the external wound a few stitches at its upper and lower extremities. Loosely pack the remainder the wound with iodoform gauze. Apply plentiful dressings. Treves advises e use of some orthopædic apparatus to secure rest for the parts.

For the first day or two after the operation the patient should be nourished y means of enemata; subsequently food should be administered through a nall soft-rubber stomach-tube passed through the mouth. This method of eding must be kept up until it is evident that the œsophageal wound has ealed. The cervical wound requires frequent dressing and the mouth must e washed at short intervals with some antiseptic lotion. The great danger o be apprehended is sepsis, especially septic mediastinitis.

Œsophageal Diverticula.—Diverticula occasionally are present in the neck nd communicate with the œsophagus or pharynx. When these are large, ood passes into them and serious symptoms, even death, may result. The condition is often unrecognized by the physician. In serious cases operation is demanded. Sometimes good results are obtained by having the patient swallow a whip cord and using this as a guide, passing bougies in a manner analogous to the passage of Gouley's tunnelled sounds over a whalebone filiform in urethral stricture (Mixter).

The Operation.—Proceed as in œsophagotomy. Retract the trachea towards the right, the sternomastoid and the sheath containing the carotid, internal jugular, and vagus to the left. Pass an œsophageal bougie through the mouth into the diverticulum, if this is possible. Recognize the diverticulum and its relations to surrounding structures. Remove the bougie. Separate the diverticulum from its surroundings. This can generally be accomplished by blunt dissection. Where the diverticulum joins the œsophagus its neck may be as thick as a man's thumb. Divide the neck of the diverticulum layer by layer close to the œsophagus. With catgut, suture the wound of the mucous membrane. The wound of the outer tunics of the neck of the divertic-

ulum is closed by an invaginating suture like Lembert's intestinal stitch. Partially close the external wound. Provide very free drainage by means of iodoform gauze. The after-treatment is the same as that for œsophagotomy. When the diverticulum is comparatively small the skin-incision need not be longer than that for œsophagotomy; but when it is large, then the incision must be longer. It is better to make an incision longer than is absolutely necessary than be cramped, while operating, through lack of room.

Girard and A. E. Halstead in cases of small diverticula avoided opening the sac. After exposing and isolating the sac, they surround it near its base by a catgut purse-string suture, invaginate the diverticulum *into* the œsophagus, pull the purse string tight and tie it. This method avoids the necessity of drainage. The pouch is said to become atrophied.

Gehle's Method.—To avoid dangers of mediastinitis, etc., especially in debilitated individuals, Gehle ("Muenchener med. Woch.") operates as follows:

Expose and isolate the diverticulum. Make a small opening into the distal end of the sac. Remove the mucous membrane as well as possible with a sharp spoon. Through the sac pass a small œsophageal tube into the stomach. Rotate the sac (and tube) on its long axis, to the extent of 180°. Fix the sac in its position of torsion by means of three catgut purse-string sutures after freshening the surfaces to be brought in contact. These sutures tie the sac firmly to the tube. Suture the opening in the sac, where the tube protrudes, to the superficial fascia. Close the wound around the sac. Gehle was able to feed his patient through the tube on the day of operation. The tube was removed on the sixth day. On the sixteenth day both solid and fluid food could be swallowed.

To the author it appears that Gehle is wrong in calling the operation "radical," but in suitable cases it seems to be the least dangerous method and at the same time the alteration in position and shape of the diverticulum promises good practical results. It is difficult to believe that curettement will sufficiently remove the mucosa to permit of obliteration of the lumen.

ŒSOPHAGEAL STRICTURE

Non-malignant strictures of the œsophagus should be treated by the passage of bougies through the mouth. It is said that dilatation may sometimes be aided by the hypodermic administration of suitable doses of thiosinamin (thiosinamin, 15; antipyrin, 7.50; water, 100. Dose, 0.5 c.c. Ten injections usually suffice) or some of its equivalents. This drug acts by softening scar tissue to such an extent that mechanical treatment is greatly facilitated. The œsophagus commonly becomes greatly distended above the site of a stricture hence it is often difficult to pass a sound into the stricture. Under these circumstances retrograde catheterization becomes proper.

Abbé's Operation.—The œsophageal pouch which forms above a stricture is a great hindrance to the passage of bougies. Abbé overcomes this difficulty by retrograde dilatation which he carries out in characteristically ingenious fashion. Perform gastrotomy. Pass a fine whale-bone bougie from below upwards until it protrudes from the mouth. To the end of the bougie tie

two long and stout threads of braided silk (whip cord will do). Pull the bougie out through the stomach wound and leave the two threads protruding from the mouth and the stomach wound. Tie the lower end of one thread to an eye at the point of a conical œsophageal bougie (Billroth). By pulling on the upper end of this thread it is easy to bring the conical tip of the bougie into the stricture and render that stricture tense. Keep up gentle traction to dilate the stricture with the bougie and at the same time pull the second cord upwards and downwards vigorously with a see-saw motion. The friction of the cord divides the stricture without damaging other strictures. The conical bougie rapidly passes upwards as the friction wears away the strictures, and the largest bougie suitable to the œsophagus is rapidly forced upwards to the mouth by a few moments' stretching and "string-sawing." The gastrotomy wound may now be closed by inversion and double suturing. Subsequent passage of a full-size bougie once a week will complete the cure, but must be continued at longer intervals for one year or more. Instead of dividing the stricture by friction and bougies, Ochsner draws a rubber tube, under tension, through the stricture. When the tension is taken off the tubing it expands and so dilates the stricture. In the course of some days, during which larger or double tubes are introduced, Ochsner obtains good results.

The author was much prejudiced against the Abbé operation, thinking it harsh and dangerous, but since seeing it performed by Abbé he has changed his views.

In any method of treatment where a gastrostomy is performed, do *not* administer thiosinamine. If this drug has any marked softening effect on the scar tissue forming the stricture it ought to have a similar and disastrous effect on the union between the stomach and the belly wall.

In one case operated on by Maurice Richardson a friable stricture existed in the œsophagus immediately below the opening of a diverticulum. Richardson split or ruptured the stricture longitudinally and repaired the defect by means of a flap provided by the diverticulum. The excess of tissue in the diverticulum was excised

Œsophagostomy may be performed below a stricture or neoplasm as a means of feeding, but gastrostomy is infinitely easier and safer to perform and is much less disagreeable to the patient subsequently. It may be performed above the stricture to permit the passage of a funnel-shaped tube from the pharynx over the chest wall to a gastric fistula (Glück). The operation is practically the same as œsophagotomy but the œsophageal wound is kept patent either by suturing or by the introduction of a rubber tube.

Cervical Œsophagectomy for malignant neoplasms is not very promising, according to deQuervain's statistics, but if performed early and thoroughly, results ought to be improved.

1. Expose the œsophagus as in œsophagotomy, the incision must be more extensive as a rule. If the thyroid adheres to the neoplasm, remove that portion of the thyroid. Carefully separate the œsophagus from the back of the trachea and larynx, paying special attention to the preservation of the recurrent laryngeal nerve. Completely isolate the affected segment of the gullet.

2. Choose the line of section at least ½ inch above and below the neoplasm.

Introduce an anchor suture of silk or hemp into the wall of the gullet above and below the part to be removed. Divide the œsophagus at the selected points. Attend to hemostasis.

3. A. A very limited portion of gullet has been removed (4 cm., 1½ inches, Czerny), restore the continuity by sutures. B. If a longer portion has been excised and approximation is impossible, anchor the upper and lower œsophageal stumps to the skin by means of sutures. Pack the wound carefully, paying special attention to protecting the mediastinum. When the wound has become sufficiently covered with granulation tissue a secondary œsophagoplasty may be attempted or a tube may be passed from the pharynx to the stomach as mentioned in œsophagostomy.

C. Primary œsophagoplasty (Arbuthnot Lane, "Brit. Med. Journ.," Jan. 7, 1911). Cut a flap of skin about 5 inches long and 2 or more inches wide (according to the amount of disease to be removed) extending horizontally from a vertical line to the left of the larynx over the anterior and right sides of the neck. Reflect the flap up to its base. Expose and excise the affected segment of gullet. Fold the skin flap in the form of a tube of appropriate diameter and suture it carefully to the œsophageal stumps. Pass a tube through the pharynx and œsophagus and leave it *in situ* for feeding purposes. (Gastrostomy is commonly performed as a preliminary operation so that nourishment can be given.) Pack the wound with gauze and partially close it with sutures.

D. Secondary œsophagoplasty has been performed by Hæcker and others but it is so similar to the primary operation that a special description is unnecessary.

Antethoracic Œsophagoplasty.—Roux ("Semaine medicale," Jan., 1907) reported an operation for impermeable œsophageal stricture. The operation consists in performing an œsophago-jejuno-gastrostomy.

1. Open the abdomen. Choose a very mobile loop of jejunum. Doubly ligate and divide four or five of the vessels passing to the loop of jejunum preserving the peripheral vascular arcades intact. Be sure that sufficient blood passes through the vascular arcades of the selected portion of gut from unligated vessels near its anal end. Apply intestinal clamps to and divide the gut at both ends of the selected segment.

2. Anastomose the open anal end of the segregated segment to the stomach near its lesser curvature.

3. With forceps make a subcutaneous tunnel from the abdominal wound to the notch of the sternum. Protect with gauze the oral end of the segregated segment of jejunum and pull it up through the tunnel. With sutures fix the upper end of the gut to the upper end of the tunnel. Pass a stomach tube through the segment of gut buried in the chest wall, into the stomach and fix it to the opening at the sternal notch.

4. With suture or Murphy's button restore the continuity of the intestine.

If the patient survives the above rather strenuous procedure the cervical œsophagus may be exposed, incised and anastomosed to the upper end of the subcutaneous tube by means of flaps of skin.

Th. Glück in cases of malignant œsophageal stricture exposes the cervical œsophagus, makes an opening in it, and unites the opening to the skin. A gastrostomy has also been performed. When the wounds are healed Glück

introduces a rubber tube through the mouth to emerge from the œsophageal fistula and pass over the chest to enter the stomach via the gastrostomy opening. The upper end of the tube is funnel shaped so as to remain in the œsophagus. Prof. Glück informed the author that his patients could swallow their food satisfactorily, the bolus passing through the rubber gullet as well as if there was peristalsis.

In one case of œsophageal cancer Kelling ("Zent. für Chir.," No. 36, 1911) found the mesentery of the small intestine too short to permit of Roux's operation being performed so he operated as follows: Laparotomy. The transverse colon was found long and mobile. At each end of the most mobile and convenient segment of colon two intestinal clamps were applied and the gut divided. After restoring the continuity of the remainder of the colon, the right end of the segregated segment was closed with sutures and the left end was anastomosed to the stomach. The meso-colon was divided below the vascular arcade, only the left portion being retained intact. A Stamm-Kader gastrostomy was performed. An incision was made through the skin from the level of the mamma on the left of the sternum down to the abdominal wound and a subcutaneous gutter formed in which the mobilized colon was planted, the skin wound being sutured over the gut. The abdominal wound was closed. After seven days the buried blind end of the colon was opened and its mucosa sutured to the skin. After 25 days cervical œsophagostomy was performed. To unite the upper end of the transplanted colon to the cervical stoma by means of a tube of skin, two parallel incisions about four finger-breadths apart were made through the skin just above the cervical opening to below the fistula on the chest. By undermining it was easy to form a tube of the skin between the incisions and so to complete the new œsophagus. The raw surfaces occasioned by the formation of the epidermal tube were covered by pedunculated flaps of skin taken from elsewhere on the chest.

Instead of using intestine in antethoracic œsophagoplasty, Bircher and Wullstein have constructed a tube entirely composed of skin just as Kelling did for part of the œsophagus in his case.

Frangenheim (German Surg. Congr., 1912) reported one case of antethoracic œsophagoplasty in which both skin and jejunum were used; the patient after the lapse of a year was still swallowing all sorts of food without trouble.

Jianu's Œsophagoplasty.—Open the abdomen. Pull the stomach forwards. Divide the great omentum transversely below the gastro-epiploic vessels. Ligate and divide the right gastro-epiploic vessels. The greater curvature of the stomach is now free from the omentum and well nourished by the left gastro-epiploic vessels.

Put a row of mattress sutures through both the anterior and posterior walls of the stomach along the line A B, Fig. 353. (With a complex machine devised by Hültl, Willy Meyer in one movement inserts a double line of wire stitches along A B and cuts between, thus saving time and soiling.)

Incise the stomach (both walls) along the line CD. Close the flap of stomach between the cut CD and the greater curvature by a double line of sutures (C′D′) so as to form it into a tube open at its distal end (C′) and continuous with the cardia at D.D′. This tube is well nourished by the left

gastro-epiploic vessels. Bury the line of mattress sutures by a row of Lembert sutures. The result is seen in Fig. 354. Make a subcutaneous tunnel from the abdominal wound upwards on the chest to about the level of the third costal cartilage. Incise the skin here. Pull the tube of stomach up through this tunnel and suture the mucous membrane at its distal extremity to the skin. The rest of the operation is the same as in some of the procedures already described.

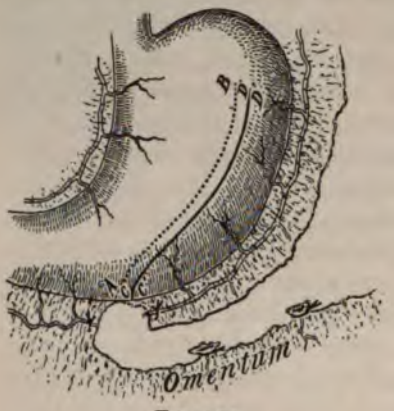


FIG. 353.

FIG. 354.

Willy Meyer (Trans. Surg. Section A. M. A., 1913) thinks it feasible to complete the Jianu operation by opening the chest in the seventh left interspace, excising the diseased œsophagus, closing the distal œsophageal stump and making an end to end anastomosis between the proximal stump of the œsophagus and the open end of the "Jianu tube." This would of course be much preferable to the antethoracic œsophagoplasty, is entirely possible technically but must ever remain extremely dangerous.

CHAPTER XXV

PHARYNGOTOMY, LARYNGOTOMY, PARTIAL LARYNGECTOMY, AND LARYNGECTOMY

SUBHYOID PHARYNGOTOMY

Place the patient on his back, the shoulders supported on a cushion and the head extended. Palpate the hyoid bone and thyroid cartilage.

Step 1.—Make a transverse cutaneous incision immediately below and parallel to the hyoid bone. If the operation is for the purpose of exposing the entrance to the larynx, an incision two inches in length is sufficient; if for the removal of a tumor of the pharynx or upper larynx, the incision must be much longer.

Step 2.—Divide the platysma myoides, and omohyoid, sternohyoid, and thyrohyoid muscles close to the hyoid bone, but leaving sufficient of their substance attached to the bone to permit of their union by suture.

Step 3.—Divide the thyrohyoid membrane along the posterior surface of the hyoid, the knife being directed backwards and upwards. Leave enough membrane attached to the bone to permit the use of sutures when closing the wound. Attend to hemostasis.

Step 4.—The mucosa now pouts into the wound during expiration; seize it with forceps and divide it. Be careful not to injure the epiglottis. Insert two catgut sutures into the upper edge of the wound in the mucosa to act as guides or tractors when closure is begun. Pull the epiglottis out of the wound and insert into it a suture to be used as a tractor. The upper part of the larynx and the lower pharynx now lie exposed, and one may proceed to remove any foreign body or accessible tumor. If the operation is done for malignant disease of the upper zone of the larynx (extrinsic disease—Semon), or if any hemorrhage is anticipated, it is well to perform a preliminary tracheotomy.

Step 5.—Close the wound in the mucosa with fine catgut sutures. Unite the thyrohyoid membrane, the divided muscles, and the skin each by a separate layer of sutures. Insert a small drain of gauze or oiled silk down to the line of suture, closing the wound in the mucosa. If a large part of the pharynx has been excised, it is wise to pack the cavity with gauze and only partially close the wound with sutures; under these circumstances a tracheotomy will have been performed.

TRANSHYOID PHARYNGOTOMY

Vallas obtains access to the pharynx by a median incision.

Step 1.—Make a median cutaneous incision from a point one finger-breadth above the hyoid to the thyroid notch. Divide the skin, subcutaneous tissue, etc., and separate the mylohyoid muscles.

Step 2.—Denude a small portion of the hyoid bone in the middle line and divide the bone with scissors or forceps. Retract the two halves of the hyoid and the attached soft structures. This gives a space about 1½ inches in width, and exposes the mucous membrane of the pharynx above and the thyrohyoid membrane below the bone.

Step 3.—Guided by a finger passed into the pharynx through the mouth open the pharynx, cutting from above downwards.

Step 4.—Having attended to the disease which necessitated operation, close the wound with several layers of sutures, after providing for drainage. It is unnecessary to suture the hyoid bone.

SUPRAHYOID PHARYNGOTOMY

Eremitsch, Grünwald, Fedoroff and others recommend suprahyoid pharyngotomy as a means of access to tumors, especially to those at the base of the tongue or on the epiglottis. Preliminary tracheotomy is unnecessary. Place the patient on his back. Support the shoulders, letting the head fall backwards.

Step 1.—Make a tranverse incision, concave upwards about ¼ inch above the hyoid. Divide the skin and platysma.

Step 2.—Retract the submaxillary gland which presents. Find the insertions of the digastric muscles and *preserve* them. Divide transversely the mylohyoids, geniohyoids and hyoglossi. Open the pharynx, being careful not to injure the epiglottis. The pharynx, soft palate, tonsils, epiglottis and the base of the tongue are well exposed. In order to operate on the base of the tongue the posterior half of the tongue must be pulled into the wound by means of a sharp retractor.

INTERCRICOTHYROTOMY. LARYNGOTOMY

This operation is commonly employed as a safe substitute for tracheotomy as a preliminary to operations upon the tongue. Butlin is an enthusiastic advocate of the operation which he uses in all such procedures as excision of the tongue, of the upper jaw, etc. It only consumes about one minute of time and renders easy work which would otherwise be troublesome.

Place the patient on his back with head thrown back and the neck supported on a firm pillow. Identify the thyroid and cricoid cartilages by touch.

Step 1.—With finger and thumb hold the larynx steady. Make an incision 1½ inches long in the middle line over the lower part of the thyroid, the cricothyroid interval, and the cricoid. Retract the edges of the wound. Expose the cricothyroid membrane. Attend to hemostasis.

FIG. 355.—Butlin's laryngotomy cannula.
X. Silver tube inserted into cannula. On this it is easy to fix a rubber tube through which the anesthetic can be administered.

Step 2.—Divide the cricothyroid membrane transversely just above the cricoid cartilage and so avoid injury to the vocal cords and the cricothyroid vessels. Penetrate the mucous membrane. Pass a closed forceps through the wound in the mucosa and open the blades so as to dilate the wound.

Step 3.—Pass a Butlin's laryngotomy cannula *into* the cavity of the larynx. The error has been made of passing the cannula (Fig. 355) into the cellular tissue with nasty results. Fix the cannula in place by tapes passed around the neck.

It is easy to administer an anesthetic through the cannula. After the operation on the tongue or mouth is completed the cannula may be removed

s soon as the patient is put to bed. No stitches are required to close the ound.

LARYNGOTOMY AND PARTIAL LARYNGECTOMY

Laryngotomy is an operation in which the larynx is split open, its interior xposed, and any foreign body or disease removed. The operation is frequently ccompanied by partial laryngectomy.

The Operation.—*Step* 1.—Perform a low tracheotomy. Insert a Trenelenburg or a Hahn cannula.

Step 2.—Make a median incision from a point immediately below the yoid bone to one just below the cricoid cartilage. Divide the cervical fascia o the full extent of the wound. Separate the sternohyoid muscles by blunt issection.

Step 3.—Incise the cricothyroid membrane after fixing the cricoid cartiage with a sharp hook or small volsella forceps. With a probe-pointed trong knife, with strong scissors, or with thin-bladed bone forceps divide he thyroid cartilage accurately in the middle line. When the cartilage is very hard, Treves advises the use of a fine saw instead of the bone forceps. In such cases probably it might be easier and less damaging to pass a Gigli wire saw through the wound in the cricothyroid membrane, behind the thyroid cartilage and out through a cut in the thyrohyoid membrane, and saw through the cartilage in the middle line from within outwards.

Step 4.—Retract the lateral halves of the thyroid cartilage with sharp hooks.

Step 5.—Remove the foreign body or tumor or excise the laryngeal contents completely.

Step 6.—Either completely or partially close the larynx with sutures. Partial closure, a gauze wick being left for twenty-four hours to drain the lower ngle of the wound in the larynx, is preferable to complete closure.

Step 7.—Replace the Trendelenburg by an ordinary tracheotomy cannula.

In Step 5 various degrees of interference may be requisite. Even in cases of rather extensive malignant disease below the vocal cords (intrinsic disease) thorough removal of the growth and surrounding soft parts *plus* energetic scraping of the cartilage often gives good results. If the growth invades the cartilage, then portions of that structure must be removed. Sir F. Semon ("Brit. Med. Journ.," Oct. 31, 1903) limits the term partial laryngectomy to cases where *not less* than one wing of the thyroid cartilage, with, possibly, a part of the cricoid and one arytenoid, is removed. Removal of small fragments of these cartilages he includes under the name "thyrotomy."

The lymphatics of the larynx may be considered as being in two groups, one above the other, below the true vocal cords. The cords have very scanty and thin lymphatics which drain into the supraglottic zone for the most part. The network of lymphatics above the vocal cords (supraglottic zone) is very dense, easily injected, covers the epiglottis, the aryteno-epiglottic folds, the superior or false vocal cords, and the ventricles of the larynx. The subglottic zone of lymphatics is not so dense as that above. "Though the two lymphatic territories of the larynx largely communicate with each other in the posterior walls of the larynx, it is rare to obtain a complete injection of the endolaryngeal

network by puncturing only one of these territories. It may be added that injections easily cross the middle line; but though the mass injected into one-half of the larynx easily passes into the mucous membrane of the other side, it is, on the other hand, exceptional for it to pass as far as the corresponding glands of that side." ("The Lymphatics," Poirier, Cuneo, Delamere. Leaf's translation.)

The great importance of the above anatomical facts is very evident and they show very clearly the reasonableness of Semon's dicta regarding the conditions required for successful thyrotomy for malignant disease. Semon gives the name "extrinsic malignant disease" to that situated in the supraglottic lymphatic zone, and "intrinsic" to that in the subglottic zone.

Conditions Essential to the Success of Thyrotomy for Malignant Disease.—

1. Operation must be restricted to *early* stages of intrinsic malignant disease.
2. Early diagnosis is indispensable.
3. Operation must be thorough. No sentimental considerations as to the amount of vocal power to be retained must interfere with the removal of sufficient healthy tissue from around the neoplasm in all directions.
4. Laryngoscopic examination rarely gives correct information as to the extent of the disease. If, on opening the larynx, the disease is found to invade the cartilages, partial laryngectomy must be performed, "or indeed any other operation, the necessity of which may become apparent when the extent and depth of infiltration of the new growth have been definitely ascertained."

Intralaryngeal operations are useless in the face of malignancy: they merely take away portions of the growth and may stimulate it to more rapid development. Even in cases where there is doubt, but malignancy is strongly suspected, thyrotomy is the proper operation. When the disease is situated on the posterior laryngeal wall or when it is too advanced for thyrotomy or partial laryngectomy to be successful, then total laryngectomy becomes a necessity. In cases of extrinsic malignant disease of the larynx subhyoid pharyngotomy gives the best access for its removal.

LARYNGECTOMY

Complete Laryngectomy.—The operation of laryngectomy is called for in cases of malignant disease of the larynx. Usually cases in which the disease has broken through the bounds of the larynx and invaded neighboring tissues are considered inoperable, but, as will be seen in succeeding pages, such cases have been successfully attacked. The greatest danger of laryngectomy is not the immediate risk of operation, but the subsequent aspiration of wound secretions into the lungs, causing pneumonia. This danger is combated by careful asepsis, or, better, antisepsis, and by using the resources of plastic surgery. After operation it is wise to encourage the patient to leave his bed as early as possible.

The Operation.—Step 1.—Perform a low tracheotomy and insert a Trendelenburg cannula to prevent the entrance of blood into the lungs.

Step 2.—Make an incision in the middle line from the hyoid bone to below the cricoid cartilage. This divides all the soft parts down to, but not through,

the cartilages and their connecting membranes. If necessary, convert the vertical into a T-shaped incision by means of a transverse cut near the hyoid bone.

Step 3.—(A) Separate the soft parts which are connected with the laryngeal cartilages, on each side, from the larynx. Do this as much as possible by blunt dissection; an occasional cut with knife or scissors will be necessary. In making this separation keep close to the cartilaginous walls of the larynx. The larynx is now exposed anteriorly and laterally; it is still united to the hyoid bone above, to the trachea below, and to the œsophagus behind.

(B) If the disease has infiltrated surrounding structures, then, of course, this step of the operation must be carried out by means of dissection beyond the disease. The operation becomes, in fact, one for the excision of a tumor in which the larynx happens to be located.

Step 4.—Stop all bleeding. Divide the thyrohyoid membrane transversely close to the upper edge of the thyroid cartilage. Injure the œsophagus as little as possible. Examine the epiglottis carefully. If it is diseased or if its appearance is doubtful, remove it. Carefully separate the posterior wall of the larynx from the œsophagus, but always bear in mind the necessity of getting beyond the disease. The larynx is now attached to the body by the trachea alone. If possible, cut through the cricoid cartilage transversely and remove the larynx. If the cricoid is diseased or in a suspicious condition, make the section through the trachea at as low a point as may be necessary.

Step 5.—Suture the divided trachea to the skin. The trachea is liable to be retracted downwards. Stop all bleeding. Introduce an œsophageal tube into the gullet to permit feeding. Pack the wound with iodoform gauze. Apply dressings. Replace the Trendelenburg cannula by an ordinary tracheotomy tube.

After-treatment.—Give the patient fluid food through the œsophageal tube, which is left *in situ*. It is probably better to omit the introduction of the œsophageal tube at the time of operation, but to pass the tube each time the patient requires nourishment. The wound should be frequently dressed and the mouth should be kept clean.

In order to avoid confusion the author has described the operation of laryngectomy as if the removal of the diseased larynx constituted the whole of the procedure. It would be almost as logical to amputate the cancerous breast without removing the fatty and lymphatic contents of the axilla as to remove the larynx without attacking the cervical lymphatics at the same time. When the larynx has been removed and provision has been made to retain control of the divided trachea (Step 5), it is easy to gain access to the cervical lymphatics and to remove them in the manner described for excision of cervical tumors or by some slight modification of that method.

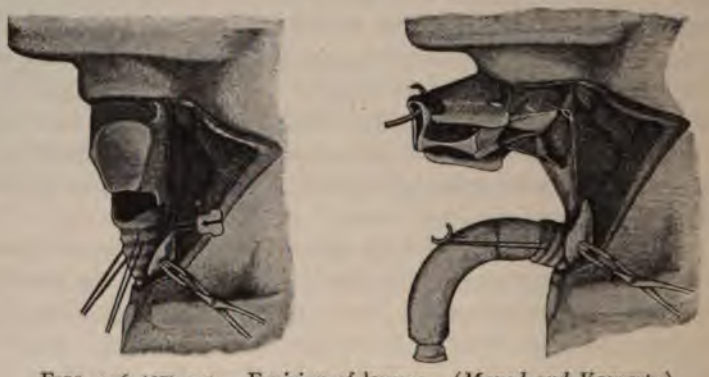
Perier's Operation.—In extirpating the larynx Perier discards the aid of a preliminary tracheotomy.

Step 1.—Make a vertical median incision from the hyoid bone down to a point well below the cricoid cartilage. Make two horizontal incisions, one at each end of the vertical cut. The wound is now I-shaped.

Step 2.—Separate the soft parts from the larynx and upper part of the

trachea, as has been already described. With a curved blunt instrument introduced laterally separate the larynx and upper portion of the trachea from the œsophagus (Fig. 356).

Step 3.—Stop all bleeding. Introduce a stout thread on each side of the trachea below the line where it is to be divided. These threads are for pur-



FIGS. 356 AND 357.—Excision of larynx. (*Monod and Vanverts.*)

poses of traction. Rapidly divide the trachea immediately below the cricoid cartilage and pull the stump upwards and forwards by means of the traction threads (Fig. 357). Introduce into the trachea a large curved cannula provided with lugs through which the traction threads may be passed and fastened. The ends of the threads are left long. The threads prevent the cannula changing its position and can still be used for traction purposes. The anesthesia is continued through the cannula.

FIG. 358.—Excision of larynx. (*Monod and Vanverts.*)

Step 4.—Complete the extirpation of the larynx. Close the wound with sutures after providing for drainage.

Step 5.—Suture the tracheal opening to the lowest angle of the wound (Fig. 358).

Th. Glück brings the tracheal stump out through a special buttonhole in the skin near the sternal notch, thus isolating it from the laryngectomy wound.

Keen's Method.—In 1898 Keen described a method of operating, the details of which lead towards safety. For several days prior to operation brush the teeth thoroughly and spray the nose and fauces with a mild antiseptic every two hours, when the patient is awake.

Step 1.—Give chloroform. Median incision from above the hyoid bone nearly to the sternum. Expose the thyrohyoid membrane, larynx, and two or more tracheal rings. Divide the isthmus of the thyroid.

Step 2.—Separate the structures to be removed from their lateral connections. Attend to hemostasis.

Step 3.—Put patient in Trendelenburg's position. Divide the trachea transversely well below the disease and below the area of the beard in men

(lest hair grow into the trachea). With three sutures fix the upper end of the trachea to the skin. Introduce an ordinary tracheotomy tube ½ inch in diameter. Secure the tube with sterile tapes passed around the neck. Continue the anesthetic through a sterile rubber tube passed into the cannula and provided with a funnel.

Step 4.—Pull the upper end of the trachea forwards, and by blunt or sharp dissection separate it from the œsophagus. Close any accidental wounds of the œsophagus at once with Lembert sutures. Remove the disease and the larynx.

Step 5.—Pull the epiglottis into the wound and remove it.

Step 6.—Suture the anterior wall of the œsophagus to the tissues just below the hyoid bone. This must be done thoroughly to prevent leakage from the mouth into the wound.

Step 7.—Remove the tracheotomy cannula and close the external wound. Provide drainage for twenty-four hours. Apply dressings above and below the tracheal opening, which is protected by any framework—*e.g.*, a pill-box without top or bottom—covered with gauze to filter the air.

After-treatment.—Put to bed without bolster or pillow. Raise the foot of the bed on a chair. Get the patient up as soon as possible (about the third day). For one or two days feed by enemata. By the third day the patient can swallow.

Föderl has paid great attention to means of avoiding postoperative pneumonia due to the aspiration into the lungs of secretions from the open wound generally left after laryngectomy. The method of operating adopted by him is based on experience gained in a case of tracheal stenosis. In this case he resected the affected portion of the trachea and restored continuity by means of a circular suture of the windpipe. The result was perfect. After the trachea has been divided, and provided it is not abnormally adherent to its surroundings, it is very easily pulled up. On the cadaver it has been shown that the larynx may be completely excised, the hyoid bone united by sutures to the first ring of the trachea the head thrown into a position of overextension, and that the sutures will still hold.

Föderl's Operation.—A preliminary tracheotomy is performed. The larynx is removed, but the epiglottis and the ary-epiglottidean folds are preserved if possible. Hemostasis is carefully secured by means of ligatures, pressure, or torsion. Unite the ends of the ary-epiglottidean folds to the posterior membranous portion of the trachea, and complete the continuity of the posterior part of the tube. The lateral and anterior portions of the windpipe are united by catgut sutures. The sutures are not tied until all of them are in place. Two or more of the anterior sutures surround the hyoid bone (submucously), catch the base of the epiglottis, and surround the first tracheal ring. After these deep sutures are tied, silk sutures are inserted through the soft parts, and help to relieve tension on the buried stitches. The external wound is closed.

Föderl remarks ("Archiv f. klin. Chir.," lviii, 803) that after his operation scarcely any more wound secretion enters the respiratory tract than does so subsequent to any of the endolaryngeal operations. A nearly linear circular wound is left, the windpipe is cut off from the rest of the wound, and there is little danger of the aspiration of wound secretions.

Föderl has operated on one case in the above manner. The patient was out of bed on the second day, able to feed himself with the œsophageal tube on the third day, and went home after two weeks. Eight months after operation there was no recurrence. Deglutition was good. Speech could be heard at thirty feet. The patient still wore a fenestrated tracheotomy tube, but he was expected to give up that before long.

The operation of laryngectomy is not absolutely limited to cases in which the disease is confined to the larynx itself. Portions of the œsophagus, etc., may be removed along with the larynx. Narath ("Archiv f. klin. Chir.," lv, 840) has published some instructive experiences on this subject. The following description is based on Narath's work:

Combined Laryngectomy and Œsophagectomy.—*Step* 1.—Perform a low tracheotomy.

Step 2.—Extend the tracheotomy wound upwards in the middle line to near the chin. Reflect the skin on either side of the neck so as to expose the larynx and surrounding structures. Isolate the diseased organs.

Step 3.—Divide the trachea below the disease. The inferior portion of trachea (*i.e.*, the portion leading to the lungs) is separated from its surroundings for a short distance and its open end brought into the tracheotomy wound in the soft parts; and is there sutured after the tracheotomy tube is removed. In the manœuvre the open end of the trachea is so bent that its opening faces directly forwards. There is little danger of blood being aspirated into the tracheal opening in its new position.

Step 4.—Remove the larynx and such portions of the œsophagus as may be diseased, remembering to cut away too much rather than too little.

Step 5.—If comparatively little of the œsophagus has been removed, it may be possible to secure closure of its lumen by means of suture. If a large portion of the anterior œsophageal wall has been removed and a small portion to the posterior, it has been possible to loosen the remnants of the posterior wall from their surroundings sufficiently to permit of the upper and lower fragments being brought together and so to obtain a continuous posterior œsophageal wall.

Step 6.—Pack the whole wound with iodoform gauze. Change the dressings whenever it is desired to nourish the patient. Nutriment is given through a stomach-tube.

As the wound heals the cutaneous edges become inverted and the granulations covered with epithelium until at last the whole space between the posterior œsophageal wall and skin is covered by epithelium. Thus a gutter is formed leading from the pharynx to the intact œsophagus below. At the lower end of the gutter the tracheal opening is seen facing forwards. The gutter must now be converted into a tube by a plastic operation very similar to the operation for hypospadias.

On each side of the gutter A, B (Fig. 359) make the skin-flaps a b c d and a′ b′ c′ d′. The *hinge* of the flap a b c d is along the line a b; that of flap a′ b′ c′ d′ is along the line a′ b′. Having separated the above flaps from the subjacent tissues, turn them inwards so that the edge d c of the one flap meets and is sutured to the edge d′ c′ of the other flap. The œsophageal gutter has now

been converted into a tube the anterior half of which is lined by epidermis. The external or raw surfaces of the two flaps (a b c d and a′ b′ c′ d′) now call for treatment. Continue the horizontal incision a, d outwards to the point e; the incision b c to f; a′ d′ to e′; b′ c′ to f′. Separate the flap e d c f from the subjacent tissues, the base of the flap being the line e f. Do the same with the flap e′ d′ c′ f′. Slide the two flaps towards each other so that the edge d c meets the edge d′ c′ in the middle line. Suture. The sliding of these flaps

FIGS. 359 AND 360.—Œsophagoplasty.

is rendered possible because the skin of the neck is so loosely attached to subjacent structures. After healing has taken place, if it is desired to make use of an artificial larynx, it will be necessary to make an opening into the pharynx at the point A (Fig. 360). A cannula is placed in the trachea. By means of a T-joint on the exposed part of the cannula a tube is led upwards over the skin through the opening at A into the pharynx. In the cannula is placed a reed. As the patient expires air the reed gives a musical note; the vibrating air is carried into the pharynx through the system of tubing described and is modified by the tongue, lips, etc., into speech. The speech is, of course, in one tone, viz., that of the reed.

CHAPTER XXVI

TRACHEOTOMY

Tracheotomy is an exceedingly simple operation under some circumstances, but when, as is often the case, one has to dispense with the use of an anesthetic and operate on a struggling, choking child, on an inconvenient table, in a badly lighted room, without proper assistance, the task of the surgeon is no light one.

There are two classical sites at which the trachea may be opened—one above, the other below, the isthmus of the thyroid gland. At the former site the trachea is much more superficial than the latter.

The High Operation.—Place the patient on his back with the shoulders raised on a pillow, the head extended, and in a good light. If possible, administer a general or local anesthetic. With the finger locate the thyroid and cricoid cartilages.

Step 1.—From a point a little below the middle of the thyroid cartilage make an incision, exactly in the middle line, downwards for a distance of about 1½ inches. Expose the deep fascia, which is attached to the thyroid car-

tilage above and the isthmus below. Divide the fascia in the middle line. By blunt dissection expose the trachea, the rings of which are easily felt with the finger. If there is not enough space between the cricoid cartilage and the isthmus of the thyroid (which lies across the third and fourth tracheal rings), make short transverse incisions, through the deep fascia where it is attached to the thyroid cartilage; this permits one to drag the isthmus downwards. In children preservation of the isthmus is of little value. Thomas Bryant stated long ago that its division did no harm, and the author, following his advice, has, when operating on children, paid no attention to preserving the thyroid isthmus, but has divided it whenever it seemed convenient to do so. St. Clair Thomson (Brit. Med. J., Oct. 11 and 25, 1919) recommends that about 20 drops of 2½ per cent. cocaine solution (in children 5 drops of 1 per cent. solution) be injected by means of a hypodermic syringe directly into the trachea as early in the operation as possible before completion of tracheal exposure. If the trachea is not opened until 10 minutes have elapsed after the injection, there will be none of that spasmodic coughing which is a real danger. Crosby Green advised this procedure in Thyrotomy for cancer of the larynx when the injection should be made through the crico-thyroid membrane.

An evident objection to injection of cocaine is that the prevention of coughing may mean serious pulmonary trouble due to retention of mucus, blood, etc., in the trachea. Therefore its use should be avoided in bronchitic or emphysematous conditions or if there is any "water-logging."

Step 2.—The trachea is now bare to the extent of three or four rings. Fasten the trachea with a sharp hook a little to one side of the middle line. Let an assistant hold the hook. Guided by the finger, introduce a knife slowly but steadily into the trachea at the lower end of the exposed area. Be careful not to push the knife in so far as to injure the posterior wall of the trachea. Cut upwards in the middle line until three tracheal rings are divided. Hold the knife in position in the trachea until, guided by the knife, one can insert into the trachea a closed hemostat or blunt-pointed narrow-bladed scissors. Withdraw the knife. Open the blades of the hemostat or scissors so as to distend the tracheal wound, and slip a tracheotomy tube into position. There are many manœuvres or dodges to facilitate the introduction of the cannula; the one described has suited the author. A few surgeons discard the cannula but suture the edges of the tracheal wound to the corresponding edges of the skin. One suture on each side suffices to keep the tracheal opening patent.

Transverse Tracheotomy.—Otto Franck ("Münch. med. Woch.," 1910, No. 6) recommends the following method:

1. Transverse incision over the cricoid. The wound gapes spontaneously, giving excellent exposure.

2. Division of the *linea mediana albicans* and retraction of the muscles down to the isthmus.

3. Transverse incision into the trachea immediately below the cricoid. When the head is extended the tracheal wound remains wide open.

4. Introduction of tracheotomy tube and suture of the excess of skin wound. When the cannula is removed the tracheal wound closes of itself.

The Low Operation.—The steps in the operation are very similar to those of the high operation. The incision begins near the cricoid cartilage and runs downwards for two inches. After the cervical fascia is divided blunt dissection will serve to expose the trachea. All veins which appear during the dissection must be drawn aside or divided between ligatures or forceps. The index finger of the left hand should be frequently put into the wound to feel the position of the trachea and to discover if any abnormal artery is in the way. The author well remembers the glee with which the late Sir John Struthers used to exhibit a specimen showing an enormous abnormal artery crossing the territory involved in a low tracheotomy. If the isthmus of the thyroid appears, it should be pulled upwards. The trachea is opened in exactly the same manner as is done in the high operation.

The low operation is not suitable in children, as in them the trachea is very deeply situated, their necks are short, and the thymus gland gets in the way. For adults and adolescents the low operation is suitable.

FIG. 361.—König's cannula.

FIG. 362.—Trendelenburg's cannula.

FIGS. 361 AND 362.—(*Esmarch and Kowalzig.*)

When the operation is performed in cases of obstruction from external pressure, *e.g.*, in cases of goître, and some obstruction exists below the tracheotomy opening, a tube should be passed down the trachea beyond the obstruction. In emergency, one may use a gum-elastic catheter for this purpose, passing it through the tracheotomy cannula. König has devised a special metal cannula with a long pliable tube which is occasionally of service (Fig. 361). When a tracheotomy tube has to be worn for a long time, one made of hard rubber is less irritating and more durable than the usual metal instrument. Fenestrated tubes permit the patient to breathe through the natural passages, and are useful to test whether it is safe to discard the cannula or not.

Trendelenburg's cannula (Figs. 362 and 363) has rubber so arranged round the intratracheal part of the tube that it can be inflated and fill up the space between the trachea and the tube, thus preventing the entrance of blood, etc., into the lungs. This cannula is of great service during certain operations on the upper air passages, as through it anesthetics may be administered.

Instead of surrounding the tube with an inflatable rubber bag, some surgeons prefer to cover the tube with compressed sponge, which when moistened swells *in situ* and serves the same purpose. (Hahn's cannula, Fig. 364.) When a tracheotomy cannula is in position, it must be retained by means of a tape passed round the neck and secured to the eye-holes provided in the instrument. The inner tube should be frequently removed and cleaned. During the first few days after operation the outer tube should never be removed except by the surgeon. Patient or nurse should never be permitted to remove the outer tube until the surgeon has satisfied himself by observation that they are capable of replacing it.

FIG. 363.—Trendelenburg's cannula *in situ*.

FIG. 364.—Hahn's cannula.

FIGS. 363 AND 364.—(*Esmarch and Kowalzig.*)

Tracheotomy is occasionally performed as a preliminary to such operations as excision of the larynx, Kocher's excision of the tongue, etc. Preliminary tracheotomy is either mediate or immediate. When the "mediate" operation is chosen, it should be performed two or three weeks before the major operation to which it is preliminary.

The advantages claimed for mediate tracheotomy are: (1) The patient has free respiration for a period of weeks and so may gain strength. (2) The patient becomes accustomed to respiring air which has not passed through the nose and mouth. (3) The tracheal wound becomes fixed to the soft parts, thus anchoring the windpipe and preventing retraction after the larynx, for example, has been excised. (4) The tracheotomy having been done beforehand, the duration of the major operation is shortened thereby.

Advocates of the immediate operation claim: (1) That the time consumed in performing tracheotomy is not sufficient seriously to influence the success of the major operation; (2) that it is unnecessary to accustom the patient beforehand to breathing through a cannula: (3) that while the patient is breathing through the cannula discharges from the cancerous tongue or larynx are liable to gravitate down the trachea, past the cannula into the lungs, and cause pneumonia, while the resisting power of the lungs is lowered from receiving air directly through the tracheotomy tube; (4) that if any attempt is to be made to restore the continuity of the windpipe after laryngectomy, the adhesions formed around the tracheotomy wound will prevent the necessary elevation or pulling up of the lower trachea.

In the opinion of the author the disadvantages of mediate tracheotomy are greater than the advantages, and the immediate operation is preferable, except when it is preliminary to excision of the tongue.

CHAPTER XXVII

FOREIGN BODIES IN TRACHEA OR BRONCHUS

Sometimes foreign bodies may be expelled from the trachea by inverting the patient, but, as a rule, the body impinging against the larynx will set up such spasm as to render its expulsion impossible. Lejars is most vigorous in his denunciation of the method. Tracheoscopy or tracheo-bronchoscopy (Killian), whether the tube be introduced through the mouth or through a tracheotomy wound, has frequently permitted the extraction of foreign bodies. This is a most valuable procedure and in most cities there are men who possess the necessary apparatus and skill to carry it out. [See Chevalier Jackson's article in Binnie's Regional Surgury, Vol I.] If tracheoscopy is not available recourse must be had to high tracheotomy. A general anesthetic is desirable. Do *not* place the patient in the dependent position until the trachea is opened. After opening the trachea and retracting the edges of the tracheal wound with retractors or stitches, the foreign body will often pop out, or may be lifted out with forceps or a scoop. If the foreign body does not promptly appear opposite the wound, investigate the lower surface of the glottis; if the body happens to be there, remove it. Lowering the patient's head and shoulders, after opening the trachea, is often helpful. Touching the mucosa of the trachea excites coughing and so may force the foreign body into view Coughing and inversion of the patient may bring a non-impacted body from the bronchus into the wound.

If the above measures are successful the author inserts a linen or silk suture in the trachea on each side of the wound and leaves these long to serve as tractors by means of which the nurse may easily open the trachea should œdema glottidis or such like accident develop. These threads may be removed after twenty-four or forty-eight hours. Cover the wound loosely with warm, moist, non-fluffy gauze. Instead of the thread tractors a tracheotomy cannula may be used. It is *not* a safe practice to close the wound entirely.

If the above means fail to give relief it is best either to suture the edges of the tracheal wound to the skin or to insert a large cannula and let the patient rest. After some hours, or next day, reopen the wound; if the body is not now coughed out, introduce a small laryngeal mirror and by the aid of a strong light investigate the trachea. If the body is seen caught in the mucosa, spray with cocaine and endeavor to extract it with laryngeal forceps or a wire loop. This may require several sittings before success is attained.

When a foreign body is impacted in a bronchus and the above measures fail to give relief, one may either attempt its extraction by means of posterior bronchotomy or await the formation of a pulmonary abscess which may be opened and drained. Unfortunately, posterior bronchotomy is a formidable operation and if the Fabian policy is adopted the patient may die before or after solidification of the lung, and pneumotomy under the most favorable circumstances is no triviality.

The bronchoscope has made a great difference in the treatment of foreign bodies in the trachea and ought to be employed but only by an expert.

POSTERIOR BRONCHOTOMY (SCHWARTZ'S OPERATION)

Anatomy.—The bronchi may be reached through the posterior mediastinum, and as this region is full of vitally important structures it is necessary to review its anatomy in a practical manner. If one excises the third to the ninth dorsal vertebræ inclusive, the posterior mediastinum will be sufficiently exposed for study. The most superficial (posterior) structures which present are vascular, viz., to the left the aorta, to the right the azygos vein. At the lower part of the exposed area these vessels lie alongside each other and hide all subjacent structures. As these vessels ascend they separate, the

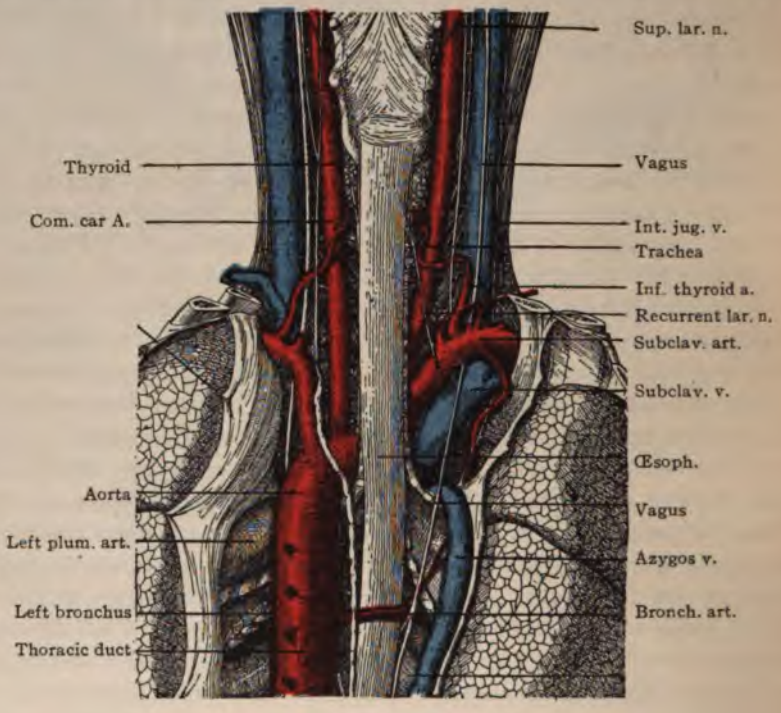


FIG. 365.—(*Poirier and Charpy.*)

aorta going to the left where at the level of the fourth dorsal vertebra it passes forwards (as the aortic arch) into the anterior mediastinum; the azygos vein ascends towards the right until it bends forwards at the level of the fourth dorsal vertebra to enter the anterior mediastinum. The aorta and azygos thus form a triangle with base above, and the floor of which is formed by the œsophagus. The apex (lower end) of the triangle is about two inches below the bifurcation of the trachea. The thoracic duct follows the inner side of the aorta and later the subclavian artery. The right and left pleuræ approach each other between the aorta and azygos behind, and the œsophagus in front. The right pleura passes behind the œsophagus in front of the azygos so as to form a sort of cul-de-sac (Quénu). The two pleuræ are loosely connected by areolar tissue. The position of the pneumogastric nerves is well seen in Fig. 365. To expose

the œsophagus it is necessary to retract the pleuræ and with them the pneumogastric nerves. Retraction of the pleuræ and of the œsophagus exposes the trachea and primary bronchi.

I. RIGHT BRONCHOTOMY

The Operation.—Place the patient in the latero-ventral position on the edge of the table with the right arm hanging over the table (Fig. 366).

Step 1.—From a point (A) at the junction of the spine and median border of the scapula make an incision to a point (B) about 1½ inches to the right of the spines of the vertebræ. From the point B, cut downwards parallel to the spinous processes for a distance of about five inches (C). Make the incision C, D which passes just below the angle of the scapula. The result

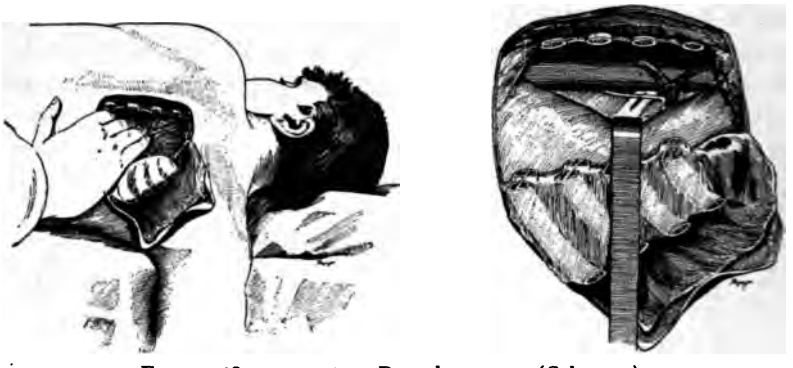
FIGS. 366 AND 367.—Bronchotomy. (*Schwartz.*)

is the flap A, B, C, D. Reflect the flap A, B, C, D outwards so as to expose the fifth, sixth, seventh and eight ribs; the flap consists of all the soft parts down to the ribs. J. D. Bryant makes the flap with its pedicle towards the spine.

Step 2.—Subperiosteally divide the spinal ends of the exposed ribs just external to the transverse process (about 1½ inches from the mid-line of the back). In the same way divide the ribs as far outwards as possible. Carefully raise the lower and inner angle of the flap, consisting of ribs and intercostal muscles, and separate it from the subjacent structures. Divide the intercostal muscles along the posterior or spinal line on which the ribs were divided, carefully exposing and tying the intercostal vessels. Divide the intercostal muscles parallel to and below the lowest rib to be mobilized. Carefully separate the parietal pleura from the flap of ribs and intercostal muscles; in doing this, gauze dissection, *i.e.*, brushing away the pleura with gauze, will be useful. Turn the flap outwards; this is possible because the ribs have been divided far out and the periosteum and intercostal structures act as a hinge (Fig. 367).

Step 3.—Carefully separate the pleura from the remnants of the ribs attached to the spine and from the side of the vertebræ. Push the pleura and the

lung outwards, away from the mediastinum (Fig. 368). As soon as the s of the vertebra is passed, the azygos vein may be seen running vertically throu the wound and at the upper end, arching forwards to reach the anterior medi tinum (Fig. 369). Continue the separation of the pleura under the arch the azygos until the œsophagus, lying on the bodies of the vertebræ, is reache External to the œsophagus lies the pneumogastric nerve. Retract the pleu outwards.



FIGS. 368 AND 369.—Bronchotomy. (*Schwartz.*)

Step 4.—Introduce the finger deeply into the wound directly in the conca of the arch of the azygos and feel the hard, prominent, posterior border of cartilaginous rings of the bronchus. Pick up the membranous posterior w of the bronchus with sharp hooks or forceps, and incise it. Remove the for body. The exposed bronchus is situated about 2¾ inches from the surf of the ribs (Glück).

Step 5.—Introduce a soft dressed drain to the wounded bronchus, possi fixing it to the bronchial wound by means of a fine stitch of catgut. Be s there is no loose "fluff" about the gauze at the end of the tube. The dra must be soft to prevent dangerous pressure necrosis. Replace the flap a sutures, leaving or making space for the exit for the drain. If the foreign bo has given rise to a peribronchial phlegmon, a more liberal drainage by mea of loose packing of gauze may be advisable.

II. LEFT BRONCHOTOMY

Place the patient in the left latero-ventral position with the left arm hangin over the edge of the table.

Steps 1 *and* 2.—Same as in right bronchotomy except th The work is d on the left side.

Step 3.—Separate the parietal pleura from the remna the spine. When the side of the vertebræ is reached, lying against the side of the spine. At the upper end passes towards (arch of aorta) the anterior me separation of the pleura under the arch of the inches. The left pneumogastric soon

pull the lung (covered by the intact pleura) outwards with a good retractor. With the finger in the depth of the wound feel the posterior prominent edges of the bronchial cartilages. The rest of the operation is the same as in right bronchotomy.

In cases of tracheal stenosis threatening life and comfort, whether the stenosis is from contraction or compression, the ideal treatment is to remove the cause. [Thyroidectomy, tracheal plastic, etc.]. Where this is impossible one may perform tracheotomy and introduce through the affected area a long cannula (König's cannula; lobster tail cannula) but the cannula irritates the air passages and gives rise to so much trouble that the cannula may require to be removed. Under these grave circumstances, the patient being "between the devil and the deep sea," Th. Glück suggests posterior bronchotomy. In one of Glück's cases of pneumectomy the patient, while convalescent from the operation and original disease, was able to breathe easily and comfortably through the thoracic wound while the nose and mouth were completely closed. This suggestion seems entirely reasonable and should be borne in mind. Posterior bronchotomy is, of course, no operation for the tyro, but in a few cases the experienced surgeon may find it of value.

CHAPTER XXVIII

GOITRE; BRONCHOCELE; STRUMA

It may not be out of place to remind the reader that there are several varieties of goitre; viz., parenchymatous, where there is uniform enlargement of the thyroid tissues; adenomatous, where the glandular tissue is in excess and forms single or multiple tumors; cystic, where from degeneration a cavity is formed filled with colloid or other fluid and often containing adenomatous masses. There is also that form known as "exophthalmic goitre," where the tumor is associated with notable general symptoms. In any of the above varieties operation may be required.

THYROID

Experiments and clinical observations have so enriched our knowledge, still woefully scant, of the function of the thyroid and the parathyroid glands that it is imperative to preface any description of the operations performed for goitre by a very few practical remarks on the thyroid and parathyroids, on hyperthyroidism, hypothyroidism and hypoparathyroidism. The thyroid is surrounded by a thin, firm membrane of fibro-elastic tissue which sends processes between the glandular units for their support and which act as pathways for the blood-vessels and lymphatics of the gland. This covering must *not* be considered as a capsule in a surgical sense; it is, surgically, part and parcel of the gland itself. Bands of dense connective tissue unite the covering of the thyroid with the trachea (ligaments of the thyroid). Fig. 370

shows how the pretracheal portion of the deep cervical fascia forms a fibrous or surgical capsule to the thyroid; it is the structure referred to as the fibrous capsule when the operation of thyroidectomy is described. Any space which may exist between the fibrous capsule and the thyroid gland is filled with loose connective tissue. The loose connective tissue is apt to be most abundant behind the lateral lobes of the gland. This connective tissue under the pressure of a goitrous enlargement becomes condensed and is what Mayo speaks of in his subcapsular operation.

The parathyroids are two or more glandular bodies which exist on each side of the neck behind the lateral lobes of the thyroid. The bodies are elliptical, "are 6 or 7 mm. long, 3 or 4 mm. broad and 1½ or 2 mm. thick. The length may be as much as 15 mm." (Piersoll.)

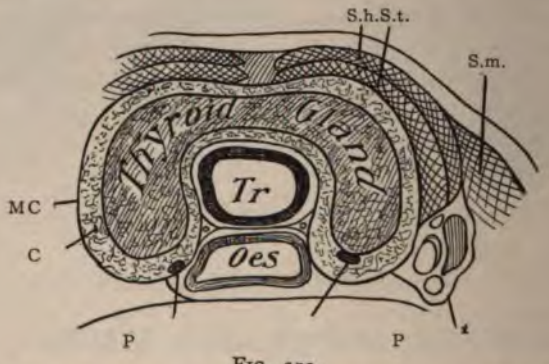


FIG. 370.

C. Fibrous or surgical capsule. P. Parathyroids. MC. Connective tissue packing, or Mayo's capsule. X. Carotid packet of vessels and nerves. Tr. Trachea. Oes. Œsophagus. S. h. Sterno-hyoid. S. t. Sterno-thyroid. S. m. Sterno-mastoid.

The parathyroids lie between the fibrous capsule and the thyroid, in the loose areolar tissue there present; they may be in contact with the thyroid or with the capsule or with both. Halsted writes, "One is likely, therefore, to encounter these little bodies, usually two on each side, at any level from the superior to the inferior pole on the postero-internal surface of the gland, but most commonly just internal to the rounded postero-external border and quite regularly near the site of the distribution of the terminal branches of the inferior thyroid artery. If the thyroid is lobulated in this situation, as is quite commonly the case, a parathyroid may be concealed in the cleft between the lobules." The parathyroids "are little ovoid, spheroid, lenticular or very flat bodies, exhibiting much variety in form and size and even in color. Externally they often resemble fat very closely in consistence as well as in color" (Halsted). The blood-supply of the parathyroids has been carefully studied by Evans (Halsted and Evans, "Annals of Surg.," xlvi, No. 4) Fig. 371. The glands are always supplied by definite parathyroid arteries which usually arise from the inferior thyroid, but frequently come from an anastomosing channel existing between the inferior and superior thyroid arteries.

Few, if any, direct vascular connections exist between the parathyroids and the connective-tissue envelope of the thyroid.

mplete excision of the thyroid glands has been followed by myxœdema y tetany. These operations were performed before the importance of arathyroids was known. Later, when the thyroid has been completely ved, experimentally, but the parathyroids preserved, myxœdema has oped, but not tetany. Hypothyroidism due to degeneration of the thyroid to cretinism or to myxœdema. Overactivity of the thyroid (hyper-

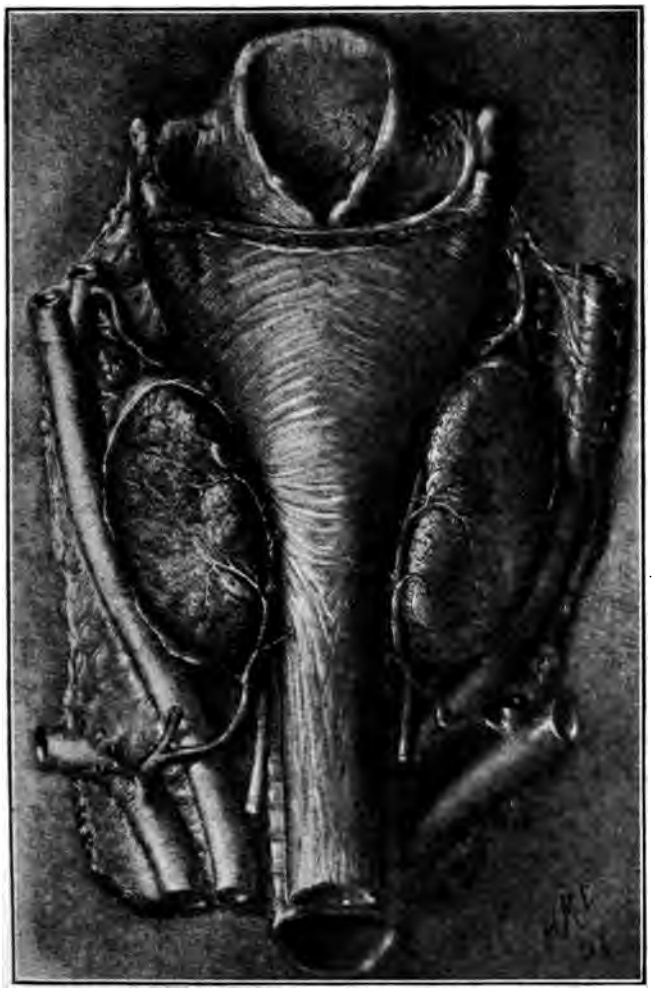


FIG. 371.—Thyroids and parathyroids seen from behind. (*Halsted and Evans.*)

roidism) gives rise to a complex of symptoms described by Graves in 1835 d by Basedow in 1840, and known by the names exophthalmic goitre, Graves' ease, Basedow's disease. Usually the thyroid is evidently enlarged in hyper-yroidism, but sometimes it is apparently normal in size. The normal ap-arance is, however, only apparent; closer examination shows that the secret-g epithelium, instead of merely lining the acini, pushes in folds into the ini, thus greatly increasing the secreting surfaces without notably increasing

the size of the gland. This is important to remember. When the parathyroid glands are excised tetany results (hypoparathyroidism). Halsted observed the early symptoms of tetany in one patient and was able to keep the disease in check by the administration of the parathyroids of beeves and later by Beebe's parathyroid-nucleoproteid. In the published statistics of partial strumectomy the death rate from tetany is 3.5%; in Kocher's clinic only ½% (Arnd). Of course there are many cases of non-fatal tetany following partial strumectomy. The reason why many cases of tetany recover is probably due to the fact that the parathyroids have not been removed, but that their circulation has been interfered with and has, in time, become reëstablished. One must remember that a lingual thyroid may constitute the whole active thyroid; that its removal may lead to disaster (see p. 216).

Indications for Strumectomy.—Very many goitres are removed for cosmetic reasons. The position, size, and character of the goitre may each constitute a positive indication for operation. Position and size may give rise to respiratory and circulatory troubles, as well as to interference with nerves. The character of the disease indicates whether or not internal treatment may be of value. Soft colloid nodules usually decrease and occasionally disappear during internal treatment. Diffuse strumata are those most suitable to medication with iodine administered externally and internally. Medical treatment must be stopped as soon as it is shown to be ineffective, or the slightest evidence of iodism or of Basedow's disease appears (De Quervain).

The local use of iodine is liable to cause adhesions around the goitre and thus render operation more difficult. Injections of iodine or such like drugs are always improper.

Almost all forms of goitre are suitable for operation if causing symptoms or deformity or increasing in size rapidly. In exophthalmic goitre (Basedow's, Graves' disease) the use of iodine is more dangerous than in other forms. Remember that Graves' disease often remains stationary or improves under any or no treatment, hence operation is by no means always called for, but remember also that, as the disease progresses, the powers of resistance decrease, hence operation must not be too long delayed.

The chief local characteristic of exophthalmic goitre is the great vascularity of the gland. The principle of treatment is to remove degenerated segments and decrease the blood-supply. Kocher, since 1890, has done this by multiple ligation of the thyroid arteries and partial excision. This work he accomplishes in several sittings. Most surgeons operate in these cases exactly as in ordinary goitre.

Kummel operates either by enucleation or resection of a portion of the goitre or partial ligation of the afferent vessels. His statistics show 70 per cent. recoveries with 5 per cent. mortality.

Kocher ("Brit. Med. Journ.," June 2, 1906), out of one hundred and forty-nine cases, had nine deaths; one hundred and forty cases were kept under observation long enough after operation to permit of a definite statement as to results; of these one hundred and thirty-one were cured and nine notably ameliorated. He writes:

"If we ligature one artery we get some, but only a slight, amelioration of the

ns. If we ligature two arteries the effect will be exactly so much greater of the function is inhibited. If we take away one lobe of the gland the still greater. If we put a ligature on three of the four arteries, we may very good result, and still better if we excise one lobe and put a ligature superior thyroid artery of the other side: it will be even more complete e combine unilateral excision with the resection of the upper and lower the other lateral lobe. If we have begun with one or two ligations, e had an unsatisfactory result, we are sure to complete it by adding a ature or by excision of one-half of the gland. In short, we may say that ation it is in our hands to guarantee a more or less complete result." ire Kocher's words, and the surgeon of Berne was *not* given to ition.

uly, 1910, Kocher reported that he had operated four hundred and ne times for Basedow's disease with a mortality of 3.4 per cent. In the nty-two cases there was no death. Glycosuria and hypertrophy of the positively contraindicate operation. To refuse operation during the eriod of the disease is to lose the best chance of success.

o's statistics in cases of exophthalmic goitre are as follows: Prior ary 1, 1906, there were fifty primary thyroidectomies with five deaths cent. operative mortality).

n January 1, 1906, to July 1, 1910, there were 459 primary thymies with sixteen deaths (3.4 per cent. operative mortality).

ng this latter period there were 267 primary ligations with eleven deaths cent. operative mortality).

reason for the death rate being higher after ligation than after thyroidis of course that the lesser operation was chosen in the more dangerous fact in patients for whom any severe operation was entirely unjustifiable.

. Mayo suggests that some of the good results following ligation of the arteries or after sympathectomy may be due to destruction of many ymphatics coming from the thyroid; this destruction of lymphatics is ulated to diminish absorption of the thyroidal secretions and thus to hyperthyroidism.

fact that alarming symptoms of hyperthyroidism very commonly folrations for Graves' disease have led to many endeavors to obviate these ns and dangers. None of the endeavors have been proven effectual ome of them may be so. A good rule to adopt is one based on common ., handle the goitre gently as so to avoid expressing thyroid juices ay be absorbed and cause trouble. Observance of this rule may do good not do harm. It probably does no good, as Crile has gently massaged n Graves' disease and has seen no evil follow. C. H. Mayo after reoitres swabbed the wound with Harrington's solution so as to close the ics and prevent absorption. He has come to the conclusion, and other agree with him, that this procedure while it may be harmless, is of no r value. Crile came to the conclusion that fear or psychic shock was a or of danger in the highly strung subjects of exophthalmic goitre, and he adopted the plan of "stealing" the goitres according to his wells ciples of anoci-association. He carries out the following measure-

two to four days before the operation: (1) Operating room clothes are worn by the patient continually. (2) Hypodermic injection of sterile water daily at 8 A. M. (3) Inhalations of Nitrous Oxide and Oxygen at 9 A. M. daily, the patient being informed that this is 'for the heart.' (4) On the day of operation morphine gr. $\frac{1}{6}$ with atropine gr. $\frac{1}{150}$ is administered at 8 A. M. in place of sterile water. (5) At 9 A. M. Nitrous Oxide and Oxygen having been administered the operation is performed. If the symptoms are severe and the operative risk great, operation is performed with the patient in bed. Complete local anesthesia is obtained by novacaine. After the goiter has been removed and hemostatis effected the wound is dressed with gauze wrung out of a 1 to 5000 watery solution of Flavine. After 24 hours the divided muscles are sutured with catgut and the wound closed.

The following are Crile's rules for after treatment: Place the patient in a comfortable position and keep him quiet with morphine in gr. $\frac{1}{6}$ doses repeated as may be necessary. Give plenty water by the mouth. Enemata of water with bicarbonate of soda and 5 per cent. glucose if required. Hypodermoclysis (under complete local anesthesia) if indicated. Ice bag to heart continuously. House inhalations (Tr. Benzoini Co. ℥j to a pint of hot water) twice daily. If the temperature reaches 101°F. apply 4 ice bags to the body; if 102°, 8 to 12 ice bags. If the temperature is 104° apply a complete ice pack as follows: Put large rubber sheets both over and under the patient to keep him dry. Entirely cover the patient (except head and neck) with about 150–200 lbs. of cracked ice. By means of an electric fan direct a current of air over the patient from the foot of the bed. As a rule under the ice pack treatment the temperature falls about 2° each hour. Discontinue the pack as soon as the temperature falls to 100°F. If there is decompensating myocarditis give Digitalin gr. $\frac{1}{25}$ hypodermatically (into muscle) every two hours until the patient is able to take digitalis by mouth, when MM. xxx of tincture of digitalis is given every three hours until the maximum effect is secured or nausea presents itself. If there is acute dilatation of the heart slowly inject intramuscularly strophanthin m.g. $\frac{1}{2}$ in 10 cc. salt solution. Klose and others think that failure to cure exophthalmic goitre by operations on the thyroid as well as the severe symptoms following thyroidectomy are due to toxic material coming from the thymus (see p. 268). Riedel performs thyroidectomy under local anesthesia using an extremely weak solution of cocaine or eucaine plus some adrenalin. The injections are massive—first under the skin and then under the deep fascia and fibrous capsule of the gland. A pint or more of the solution is used. This of course obscures to some extent anatomic relationships *but* it so distends the spaces in the areolar tissue between the fibrous capsule and the true capsule of the gland that it practically separates the gland from its surroundings so that it is easy to find and ligate the vessels and remove the gland. If Crile's ideas are correct regarding reflex nerve impulses causing ejaculation of thyroid juice, then Riedel's massive injections are well calculated to cut off these impulses and at the same time facilitate the operation. Mayo's rules for operation in Graves' disease are: If the condition is fair, operate; if the pulse is 130 to 160, or if it suddenly fluctuates in tension and rapidity, if there is anæmia with swelling of the feet, the patients are placed upon belladonna treatment for some days. The more severe types are also given

X-ray exposures in addition, a treatment which is continued from two to six weeks.

Whenever the symptoms are severe Mayo contents himself with ligating the superior pole of the thyroid on one or both sides: later, if necessary, he removes

FIG. 372.—Posterior view of trachea, etc., showing course of recurrent laryngeal nerve. (*Esmarch and Kowalzig.*)

FIG. 373.—Superficial veins over a goitre. (*Esmarch and Kowalzig.*)

part of the gland when the patient is in better condition. In very grave cases he treats the goitre by injections of boiling water after the manner of Porter.

Besides the two lateral lobes and isthmus which compose the thyroid gland, the remnant of the thyroglossal duct running up from the isthmus often forms an extra lobe, the pyramidal lobe, and along its course there may be developed irregular masses of glandular tissue—accessory thyroids. The frequent presence of these extra masses of thyroid is not surprising, the thyroid itself being developed from the thyroglossal duct; surgically they are of importance, as their presence is calculated to confuse the operator, ignorant of their existence.

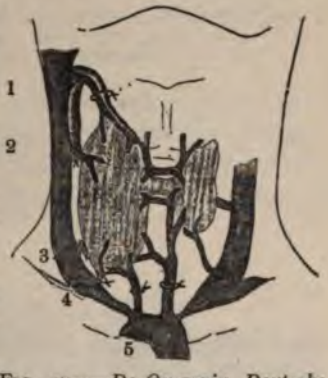


FIG. 374.—*De Quervain, Deutsche Leitschf. chir.*, CXVI, 574.

1. Superior thyroid artery and vein. 2. Superior thyroid vein. 3. Accessory inferior thyroid vein. 4. Inferior thyroid vein. 5. Thyroidea ima veins (chief and accessory).

The thyroid is surrounded by a strong covering of fascia—fibrous capsule. When a goitre is present in the gland (adenoma or cyst), it is, of course, surrounded by more or less altered glandular tissue—glandular capsule. The word capsule, being applied both to the outer fibrous covering and to the glandular tissue inside which the tumor lies, leads to confusion when methods of operating are described. In the succeeding pages the outer or surgical capsule will be called the fibrous; the inner, the glandular capsule.

The arteries of the thyroid are: (*a*) The superior thyroid, entering the upper pole of the lateral lobe; (*b*) the inferior thyroid, entering the posterior surface of

the lower pole and in close and, surgically, dangerous relation to the recurrent laryngeal nerve (Fig. 372); (*c*) the thyroidea ima, entering the isthmus from below.

The veins of the thyroid are of very great importance; a study of Kocher's schemata (Figs. 373 and 374) will give a fair idea of their location and importance.

Operations for the cure of goitre may be divided into three groups: I. Excision; II. Intraglandular enucleation; III. Incision and evacuation.

I. EXCISION

Complete excision of the thyroid gland is an unjustifiable operation, as it is followed by fatal consequences. As in the case of other organs, nature has been lavish in her provision of functional material in the thyroid, and it is safe to say that one-fourth of the gland is sufficient for the maintenance of health.

De Quervain's methods of operating upon the thyroid are worthy of serious study.

1. *Ligation of the Inferior Thyroid Artery External to the Fibrous Capsule of the Gland.*—Through Kocher's collar incision divide the platysma and expose the

FIG. 375.

inner margin of the sternomastoid muscle. Retract the muscle gently outwards (Fig. 375). Make a vertical incision about 1 inch in length through the external fascia of the sternohyoid; separate this fascia from the muscle and retract it outwards with the sternomastoid. It is now easy to penetrate the loose connective tissue until the carotid packet of vessels and nerve is reached. Note the carotid tubercle of the transverse process of the 6th cervical vertebra; about ⅜ inch (1 cm.) below this the convex curve of the inferior thyroid artery can be felt immediately to the inner side of the carotid packet. The artery may be found slightly higher or lower in individual cases. The advantage of this route is that when the sternohyoid and sternothyroid muscles are to the in-

ner side of the line of dissection one is in little danger of opening the fibrous capsule of the thyroid and thus one avoids interfering with the numerous veins which lie between the gland and its fibrous capsule.

With suitable retractors gently retract the sternohyoid and thyroid muscles and the thyroid gland towards the median line, the sternomastoid and the

FIG. 376.—*de Quervain. Deutsche Zeitsch. f. Chir.*, cxvi, 574.

FIG. 377.—*de Quervain. Deutsche Zeitsch. f. Chir.*, cxvi, 574.

outer portion of the sheath of the sternohyoid being at the same time retracted outwards.

With dissecting forceps clear the inferior thyroid artery from the loose connective tissue around it and ligate it. The only vein which interferes in the dissection is the median thyroid and it, as a rule, is at a higher level.

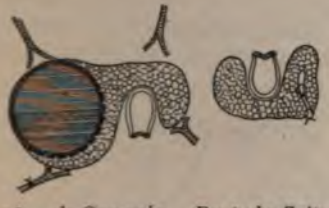


FIG. 378.—*de Quervain. Deutsche Zeitsch. f. Chir.*, cxvi, 574.

FIG. 379.—*de Quervain. Deutsche Zeitsch. f. Chir.*, cxvi, 574.

2. The inferior thyroid artery has been ligated, the skin and platysma have been reflected from the whole thyroid region. Make a longitudinal median incision between the two sternohyoid and sternothyroid muscles and penetrate the fibrous capsule of the gland. In the usual manner dislocate the affected

FIG. 380.—*de Quervain. Deutsche Zeitsch. f. Chir.*, cxvi, 574.

FIG. 381.—*de Quervain. Deutsche Zeitsch. f. Chir.*, cxvi, 574.

lobe of the thyroid inwards. There will be much less venous bleeding than in the usual operation because of the ligation of the inferior artery. From this point onwards De Quervain follows no "hard and fast" method of operating. According to the needs of the individual case he performs resection, enucleation

trachea. If a general anesthetic is being used, warn the anesthetist before dislocating the gland.

Step 3.—Systematic ligation of vessels.

(*a*) With Kocher's director push the fibrous capsule inwards and outwards from the upper pole of the thyroid until the superior thyroid artery and vein are isolated like a pedicle. Divide these between ligatures applied tightly (Fig. 389).

FIG. 387.—(*Kocher.*)

(*b*) Vigorously retract the muscles (sternomastoid, etc.) of the affected side. Firmly pull the goitre over towards the sound side (Fig. 388). The inferior thyroid artery lies on the deep muscles of the neck and may be felt as a transverse or oblique pulsating cord running from the outer side, under the carotid to the thyroid gland, where that structure is attached to the trachea. Isolate the artery with great care and precision, because close to it is the recurrent laryngeal nerve. Only apply one ligature to the vessel. Many surgeons ligate each branch of the inferior thyroid close to the gland and so avoid the nerve.

FIG. 388.—(*Kocher.*)

FIG. 389.—(*Kocher.*)

(*c*) At the lower pole of the tumor on its median side look for, doubly ligate, and divide the thyroidea ima artery and the accompanying veins (Fig. 391).

Step 4.—Isolate the thyroid isthmus. Doubly ligate and divide all vessels visible on it. Catch the isthmus in strong forceps (Fig. 392) and crush it forcibly. Remove the crushing forceps. Doubly ligate the gutter crushed in the isthmus with single or chain ligatures and divide it.

Step 5.—The gland now remains attached to the trachea and cricoid by its inner margin. If this portion of the gland is healthy, cut away the gland in

such a manner as to leave a thin layer *in situ*, protecting the recurrent laryngeal nerve. Ligate any bleeding vessels.

Step 6.—Wash the wound with hot solution. Examine for any bleeding points. Return any divided muscles to their normal place and unite them by sutures. Provide for drainage, especially in exophthalmic cases. Close

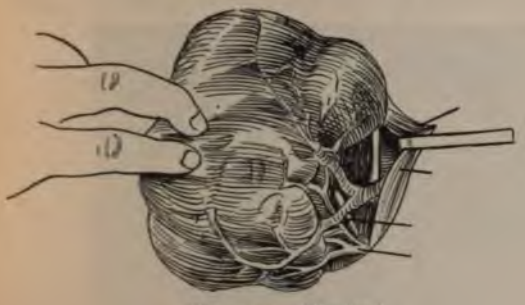


FIG. 390.—(*Kocher.*)

FIG. 391.—(*Kocher.*)

the wound. Apply dressings. The drainage must be removed in twenty-four hours if no fluid blood is escaping.

Method B.—Mayo's Operation.—Step 1.—As in method A.

Step 2.—With the fingers separate the fibrous capsule from the anterior surface of the gland, at the same time pulling the muscles and fibrous capsule outwards with blunt retractors or forceps. Doubly ligate and divide any

FIG. 392.—(*Kocher.*)

accessory veins. Expose and elevate the upper pole of the thyroid, doubly ligate and divide the superior thyroid vessels.

Step 3.—Elevate the lower pole of the thyroid and bring it into the wound. If necessary make an incision along the outer posterior border of the thyroid so as to divide any condensed areolar tissue which may be adherent to the peritoneal-like investment of the gland. This incision is not always necessary.

or a combination of these methods, and like most surgeons he always leaves a substantial portion of the posterior surface of the gland in order to avoid injuring the recurrent laryngeal nerve and the parathyroids.

In performing resection the following may be taken as a type: Ligate the upper pole of the lobe of the gland to be removed. Note and clamp the vessels running over the gland at the chosen site for section (Fig. 384).

FIG. 382.—*de Quervain. Deutsche Zeitsch. f. Chir.*, cxvi, 574.

FIG. 383.—*de Quervain. Deutsche Zeitsch. f. Chir.*, cxvi, 574.

Incise the *true* capsule along the anterior part of the outer surface of the gland. Make a similar incision through the true capsule to the inner side of the lobe. Excise all the gland lying between these two incisions, leaving the posterior portion of the true capsule with a moderate amount of glandular tissue attached to it.

FIG. 384.—*de Quervain. Deutsche Zeitsch. f. Chir.*, cxvi, 574.

Attend to hemostasis. Suture the remnant of the gland close to the wound after providing for drainage. Figures 376 to 381 show types of resection. When enucleation is preferable to resection one or several of the thyroid arteries may require preliminary ligation. Figures 382 and 383 show various types of enucleation.

Partial Excision—Excision of One Lobe

Method A.—Kocher's Transverse Incision.—Step 1.—Over the most prominent part of the tumor make a slightly curved transverse incision (concavity upwards) from the outer surface of one sternomastoid muscle to the corresponding point on the other. Make the incision too long rather than too short, as thorough exposure is the key to safety. Divide the skin and platysma. Reflect the divided tissues upwards and downwards; the sternohyoid, sterno-

thyroid, omohyoid, and inner margin of the sternomastoid muscles lie more or less exposed. Find the anatomic middle line of the neck. Remember that a unilateral goitre pushes this line towards the opposite side (Figs. 385 In the median line divide the fascia uniting the right and left muscle groups. Do this extensively both upwards and downwards under guidance of the finger passed under the fascia. Pass the finger under the muscles of

FIG. 385.—(*Kocher.*)

the diseased side immediately below the larynx and, if necessary, divide them transversely to the extent necessary for *thorough* exposure of the tumor. It is well to divide the muscles between clamps so as to prevent staining of the wound with blood. Demonstrate the fibrous capsule of the thyroid and split it without injuring the gland beneath. Division of the fibrous capsule is absolutely essential.

FIG. 386.—(*Kocher.*)

Step 2.—With the finger separate the fibrous capsule from the anterior surface of the gland, at the same time pulling the muscles and fibrous capsule outwards with blunt retractors. The goitrous thyroid now presents, covered by a peritoneal-like membrane (Fig. 394). Any veins (accessory veins) passing from the fibrous capsule to the gland must be doubly ligated and divided. Do the same for the outer and posterior surfaces (Figs. 386, 387, and 388). Now dislocate the goitre and pull it out of the wound. This removes pressure from

trachea. If a general anesthetic is being used, warn the anesthetist before dislocating the gland.

Step 3.—Systematic ligation of vessels.

(*a*) With Kocher's director push the fibrous capsule inwards and outwards from the upper pole of the thyroid until the superior thyroid artery and vein are isolated like a pedicle. Divide these between ligatures applied tightly (Fig. 389).

FIG. 387.—(*Kocher.*)

(*b*) Vigorously retract the muscles (sternomastoid, etc.) of the affected side. Firmly pull the goitre over towards the sound side (Fig. 388). The inferior thyroid artery lies on the deep muscles of the neck and may be felt as a transverse or oblique pulsating cord running from the outer side, under the carotid to the thyroid gland, where that structure is attached to the trachea. Isolate the artery with great care and precision, because close to it is the recurrent laryngeal nerve. Only apply one ligature to the vessel. Many surgeons ligate each branch of the inferior thyroid close to the gland and so avoid the nerve.

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such a manner as to leave a thin layer *in situ*, protecting the recurrent laryngeal nerve. Ligate any bleeding vessels.

Step 6.—Wash the wound with hot solution. Examine for any bleeding points. Return any divided muscles to their normal place and unite them by sutures. Provide for drainage, especially in exophthalmic cases. Close

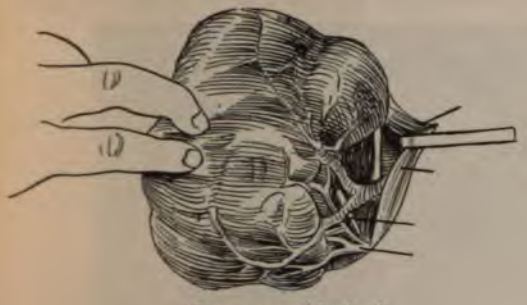


FIG. 390.—(*Kocher.*)

FIG. 391.—(*Kocher.*)

the wound. Apply dressings. The drainage must be removed in twenty-four hours if no fluid blood is escaping.

Method B.—Mayo's Operation.—Step 1.—As in method A.

Step 2.—With the fingers separate the fibrous capsule from the anterior surface of the gland, at the same time pulling the muscles and fibrous capsule outwards with blunt retractors or forceps. Doubly ligate and divide any

FIG. 392.—(*Kocher.*)

accessory veins. Expose and elevate the upper pole of the thyroid; doubly ligate and divide the superior thyroid vessels.

Step 3.—Elevate the lower pole of the thyroid and bring it into the wound. If necessary make an incision along the outer posterior border of the thyroid so as to divide any condensed areolar tissue which may be adherent to the peritoneal-like investment of the gland. This incision is not always necessary.

With a piece of gauze wipe or brush all areolar tissue adherent to the posterior surface of the gland from the gland so that that surface of the gland has no *moss* of areolar tissue left adherent to it, but presents a smooth peritoneal-like appearance. If this is done carefully and every bit of areolar tissue, which may have penetrated into sulci on the gland surface, has been brushed off and left adherent to the fibrous capsule, then the parathyroids must also have been brushed off and preserved. Continue this gauze dissection or brushing to the

FIG. 393.—(*Mayo.*)

middle line. Ligate the inferior thyroid artery close to the tumor as the gauze dissection is being carried out. This leaves the recurrent laryngeal nerve behind and usually out of sight.

Steps 4, 5 *and* 6.—As in method A.

Method C.—Halsted's operation is the same as Kocher's or Mayo's up to a certain point. The following quotation from Halsted gives the main points of his method. "Contrary to the universal custom, I do not, as a rule, complete at this moment the full delivery of the entire gland, for fear of soiling, but grasp very firmly between the thumb and finger the superior pole and pull it forwards and towards the mid-line far enough to make the ultraligation of the superior thyroid vessels perfectly easy. Attempts to completely dislocate the

entire gland of the inferior pole in this manner at this stage of the operation may cause the rupture of some delicate blood-vessels and consequent staining of the field containing the parathyroid glandules. But, if judiciously done in the manner described, the superior pole may be fearlessly grasped, because at this horizontal level there are no vessels behind the superior pole to be torn. When the superior thyroid vessels have been safely passed by the thumb or finger, one may proceed with considerable roughness and without fear of hemorrhage to dislocate even the highest and deepest superior pole. This grasp of

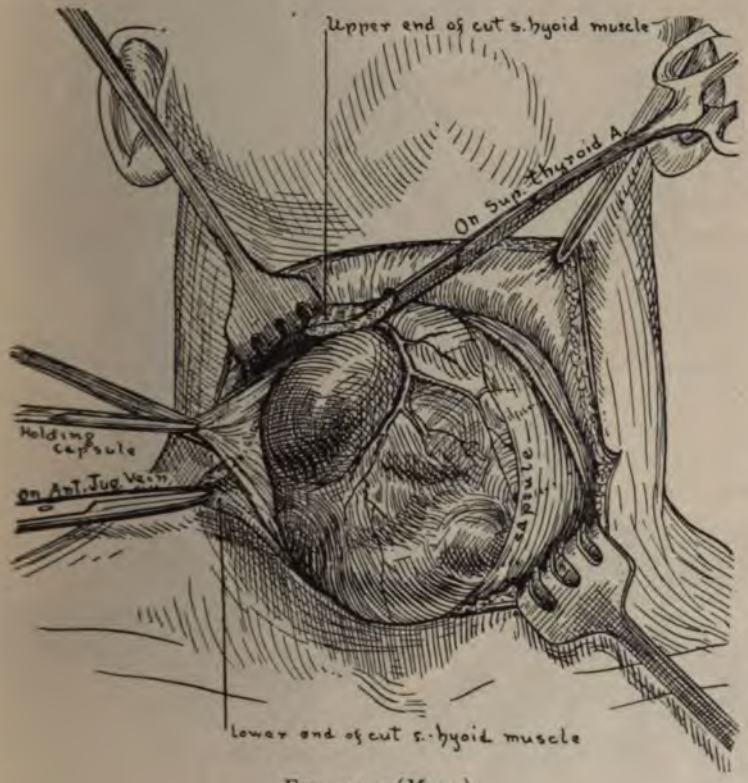


FIG. 394.—(*Mayo.*)

the upper portion of the lobe, putting on stretch the superior thyroid vessels, must not be relinquished until released by the ultradivision of the finest branches distributed to the thyroid gland in the vicinity of the superior pole. The upper end being thus liberated the delivery of the entire lobe is continued, and without the tearing of the blood-vessels. From this step on, throughout the operation, until the last vessel has been divided, the thyroid lobe must be firmly drawn towards the opposite side, alternate relaxation and compression and undue pressure on the trachea being carefully avoided. From above downwards and from before backwards the vessels as they bind or as they present must be clamped and divided at their point of entrance into the gland, as far peripherally as possible. Except in the case of the larger branches it is usually unnecessary to clamp the distal end of the cut vessel, hemorrhage from the gland side being

prevented by the pressure exerted on the thyroid lobe by the unremitting traction towards the opposite side of the neck. By this method the recurrent laryngeal nerve, usually seen, is little endangered. In the course of the liberation of the lobe the nerve may be dragged well to the front of the trachea; of the right nerve this is particularly true. When in the immediate neighborhood

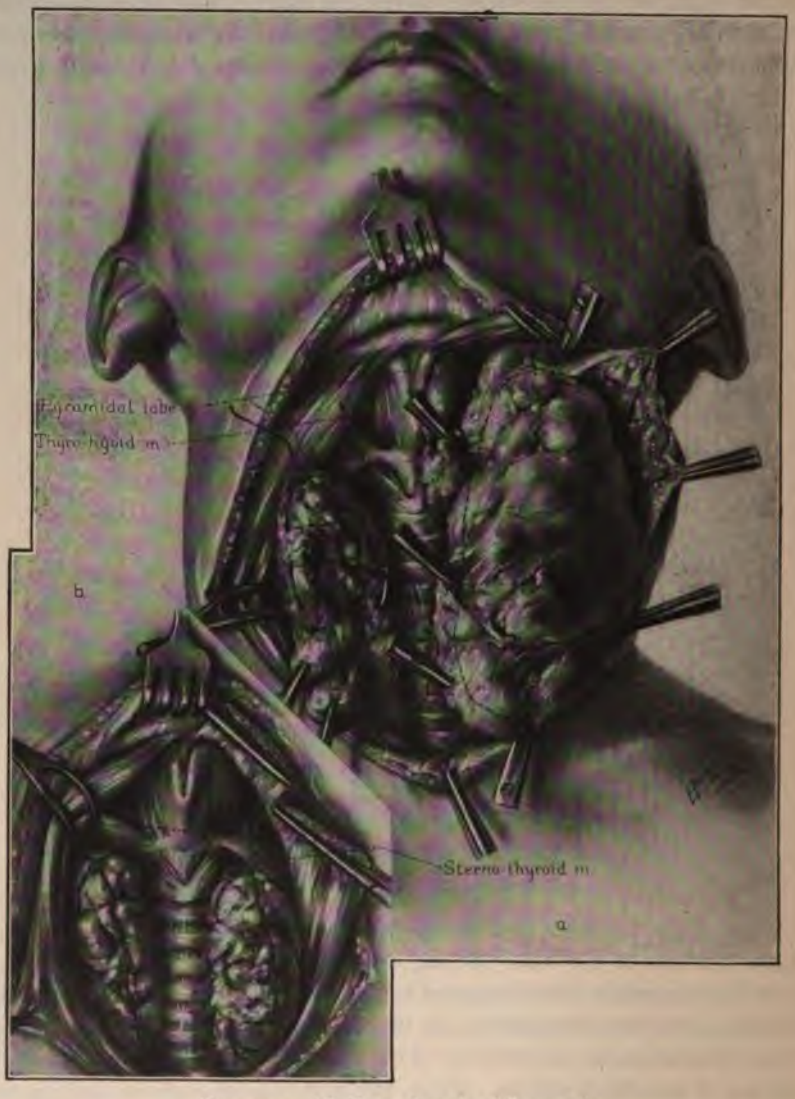


FIG. 395.—(*Balfour, Annals of Surgery.*)

of this nerve, at what might erroneously be termed the hilus of the thyroid lobe, one plunges the sharp-pointed clamps into the thyroid gland, seizing the binding vessels after they have disappeared from view in its substance. When the habit is well acquired, little if any time is lost by practising the clean, bloodless method of operating for goitre. The operation can be carefully performed in about the time required for its detailed description."

Method D.—Angular Incision (*Kocher*).—Beginning on the sternomastoid uscle at the level of the thyroid cartilage, make an incision through the skin ıd platysma, reaching the median line and following the direction of the natu-l folds or creases of the skin. Continue the incision downwards in the middle ıe to the notch of the sternum. Reflect the angular skin-flap and expose the ernomastoid, which must be retracted outwards. The rest of the operation the same as in Method A. This method of exposure is of much value in cases here the goitre extends far upwards or downwards.

Method E.—v. Mikulicz's Method of Resection.—The following description from v. Mikulicz's article, quoted by Berry ("Diseases of the Thyroid Gland"): I began the operation, intending to perform the ordinary one of removal of the t lobe, and hoping to be able to leave the right intact. In the course of the eration, however, it became evident that the right lobe lay partly behind the ernum, and would, if left, prove a source of danger to the patient. So instead doing the usual extirpation, I resected this lobe in the following manner: rst of all it was isolated as far as possible in the usual way with blunt instruents. The smaller blood-vessels were tied with double catgut sutures. I en tied the superior thyroid artery and vein in the ordinary manner at the mmit of the lobe; also the superficial vessels passing to the lower part of the and. I now, by means of short snips of the scissors, freed that portion of the mor which was adherent to the front and side of the trachea, but took care ot to go too far back, so as not to come into collision with the recurrent laryn-al nerve. Eventually the whole tumor was attached only to the angle be-veen the trachea and œsophagus, where it covered the recurrent nerve and ferior thyroid artery. This attached portion, the hilus of the gland, I treated ke the short, thick pedicle of an ovarian tumor. . . . While my assistant ith his fingers compressed the vessels entering the hilus, I split the pedicle ngthwise with blunt scissors into several portions, seized each of these in a rong pair of pressure forceps, and placed catgut ligatures in each of the clefts o formed. Then the goitrous mass was cut off with scissors, leaving a pedicle f 5 to 10 mm. ($\frac{1}{5}$–$\frac{2}{5}$ inch) in length. The forceps squeezed out nearly all the landular tissue, leaving in their grasp little but connective tissue. The result as that the catgut ligatures could easily and safely be placed around the sepa-ated portions of the pedicle. Not a drop of blood came away from the cut urfaces; only here and there in the intervals was a little oozing; this slight emorrhage was easily stopped by the application of a few ligatures. The emainder of the gland had now shrunk to a lump about as large as a chestnut hich lay in the angle between the trachea and œsophagus. Neither recurrent erve nor inferior thyroid artery came into view on this side."

The above operation has been frequently repeated and has proved very uccessful. The advantages of the procedure are: (*a*) avoidance of the recur-ent nerve; (*b*) avoidance of injury to the parathyroids; (*c*) retention of portions f the lobes attacked, and hence the possibility of removing parts of both lobes.

Donald Balfour (Annals Surg., May, 1914) describes a method almost the ame as that of Mikulicz. It is particularly suitable for non-toxic goitres where he operation is for the relief of pressure symptoms and the removal of deformity.

Expose the thyroid through the usual collar incision. If both lobes are en

larged, dislocate them both. Determine how much glandular tissue must be removed from each side to ensure symmetry and cure. Divide the isthmus, if possible, between clamps. Free the isthmus and lobe on one side from their tracheal attachments anteriorly and laterally sufficiently to relieve all pressure and to permit of proper suturing after resection. Do the same to the other half of the gland.

Apply a series of Ochsner forceps around the area to be resected: one forceps about 1 inch from the upper pole, one near the lower pole, three or four laterally on the larger vessels in the capsule, and two or three on the tracheal side. These forceps mark the limits of the resection and enable one to control bleeding by traction on them along with support of the lobe from behind with the finger. Make an incision through the capsule around the lobe just within the circle of

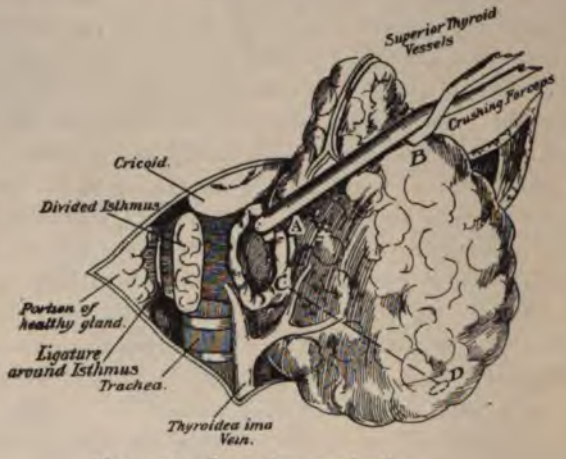


FIG. 396.—Resection-enucleation.

forceps (Fig. 395). "Wedge" out the interior of the gland. Multiple adenomas and masses of colloid are easily enucleated by the finger. The superior and inferior poles and a layer of gland tissue covering the posterior capsule are left intact. Bring the walls of the wounded gland into contact and fix them together by a continuous mattress suture of catgut introduced behind the row of Ochsner forceps. Remove the forceps. Introduce sufficient stitches to complete the closure of the glandular wound and to assure hemostasis.

Method F.—Resection-enucleation (Kocher).—This method is very like that of v. Mikulicz, but avoids leaving large ligated masses near the location of the recurrent nerve. Kocher has noticed that when many large pedicles are ligated near the nerve the necessary contraction of the tissues by the ligature often causes injury to it.

The Operation.—Step 1.—Expose the anterior surface of the diseased half of the thyroid as in Method A. Crush (with forceps), ligate, and divide the isthmus close to the disease.

Step 2.—Through the cut surface of the isthmus the goitrous nodule will present (Fig. 396). Beginning at the isthmus wound, with the finger or Kocher's director penetrate the glandular capsule down to the disease and separate the

former from the nodule along the lines A B and C D. Note that the separation of glandular capsule from goitrous nodule is only along these two lines. With strong forceps crush the glandular capsule along the lines of separation, remove the forceps, apply ligatures to the crushed tissue, and divide the glandular capsule.

Step 3.—Grasp the goitrous nodule and overlying glandular capsule and separate this mass from the posterior portion of the glandular capsule until all that connects the goitrous mass to the body is the outer portion of the glandular capsule (B D, Fig. 396) well external to the line of the recurrent nerve. Crush this portion of the capsule; ligate and divide it.

By the above procedure the diseased tissues are removed, and with them the anterior portion of the gland. All the posterior surface of the gland is left, which is advantageous because danger to the recurrent nerve, and the parathyroids, is avoided and much useful glandular tissue is retained. Hemorrhage is less than in enucleation. Kocher says that this operation, while very valuable, is of more limited application than excision. It is inapplicable in cases of diffuse follicular colloid degeneration.

Method G.—Freeman's Method (Surg. Gyn. and Obst., July, 1914).—Dislocate the gland through the usual collar incision. Separate ligation of the superior thyroids may be practised if desired. Pull the lobe forwards so as to put its attachments on the stretch and form more or less of a pedicle next to the trachea.

Thread *both* ends of a 12-inch loop of strong silk or fishing line through the eye of a probe and pass it from behind forwards through the substance of the gland near its attachments.

Introduce several such loops of thread through the gland, one near each end and one or more near the centre. Place a segment of strong wire (No. 17 German silver, "orthodontia wire") through the loops behind the gland and a similar wire between the ends of the thread in front of the gland. Tie the threads over the anterior wire firmly enough to control the circulation without injuriously crushing the glandular tissue. About ½ inch distal to the wires cut away the lobe in a more or less wedge-shaped fashion. Suture the wound with a continuous catgut stitch to cover the raw surface and prevent subsequent bleeding. Pull the wires out of the loops and remove the latter. Close the wound as usual. Freeman has used this method successfully in about twenty goitres of moderate size and excessive vascularity—as in Graves' disease.

II. INTRAGLANDULAR ENUCLEATION

Step 1.—Expose the anterior surface of the diseased lobe by Method A or D. (See "Excision.")

Step 2.—Note the most prominent part of the tumor, and at this point freely incise the glandular capsule. Before incising, clamp or doubly ligate any prominent vessels. Be sure to penetrate to, but not into, the tumor. It is not always necessary to incise the glandular capsule as the tumor may have so grown as to push aside all the gland tissue which originally covered it. In such a case it is easy to enucleate the growth by brushing aside with gauze all tissue adherent to it.

Step 3.—With blunt dissection, using the finger, Kocher's director, or closed blunt scissors, shell the tumor out of its glandular capsule. Sometimes this is more easily accomplished if the fluid contents are drawn off, as in the case of a large ovarian cyst. The shelling-out must be done rapidly, as bleeding is often abundant. The surgeon must always keep his instrument close against the tumor-wall, otherwise the vascular glandular capsule will be injured and more bleeding provoked.

Step 4.—Immediately on the removal of the tumor temporarily pack the cavity with gauze and pull the whole cavity forwards. Gradually remove the gauze, and with forceps, ligatures, and catgut stitches stop hemorrhage. The hand placed behind the thyroid can press the floor of the wound cavity forwards within reach and control. Hemostasis must be absolute, as primary union is of great importance.

Step 5.—Provide for drainage for twenty-four hours. A tubular drain is best. Close the wound with sutures. For this purpose Berry uses three layers of fine sutures. One layer obliterates the cavity in the gland, another unites the muscles, and a third, the skin-wound.

Where large multilocular cysts are present F. J. Shepherd ties and divides the superior thyroid vessels, delivers the gland and enucleates the tumor. This leaves a thin layer of gland tissue behind, and there is no danger of injuring the recurrent nerve. Occasionally Shepherd ties the inferior thyroid as well as the superior. In the light of Evans' researches into the blood supply of the parathyroids, ligation of the inferior thyroid artery becames a matter of much greater gravity than it was formerly thought to be.

III. INCISION AND EVACUATION: MARSUPIALIZATION

In certain cases of cystic goitre where repeated attacks of inflammation have caused the formation of many adhesions none of the preceding methods are applicable, and a simpler operation must be done.

Step 1.—Make an incision over the most prominent portion of the tumor and expose a few inches of its surface.

Step 2.—Doubly ligate the vessels of the tumor capsule (both fibrous and glandular capsule) and incise the tumor. Stitch the edges of the wound in the cyst-wall to the skin.

Step 3.—Explore the cyst with the finger and shell out all degenerated colloid masses. Stop bleeding by means of forceps, ligatures, hemostatic sutures, hot water, and packing. Drain the cavity.

The great objection to this procedure is the open wound which is left, the dangers of subsequent infection, and the possible persistence of a fistula; its advantages are ease of accomplishment and immediate safety. The operation has a distinct though limited field of usefulness.

IV. TRANSPLANTATION OF THYROID OR PARATHYROID GLANDULAR TISSUE

Payr ("German Surg. Congress," 1906) has made some remarkable experiments on animals and has endeavored to prevent the tetany and cachexia strumipriva which follow complete thyroidectomy. In animals he implanted

fragments of thyroid gland into a pouch made in the spleen. Hemorrhage ceased as soon as the "living tampon" was sutured in place. Omentum was stitched over the splenic wound. After some days the rest of the thyroid gland was removed without ill resulting. As a control Payr in some cases subsequently removed the spleen and caused death from tetany.

Encouraged by the above Payr operated on a girl of six years, a complete idiot who had been treated for three years with thyroid tablets unsuccessfully. He removed a part of the healthy thyroid from the patient's mother and immediately implanted it in the child's spleen. Both patients recovered from the operation. The psychic improvement in the child was "incontestable." Payr has noticed that grafts from ductless glands generally do well in the spleen while those from excretory glands do not do so well.

Following Payr's lead, Halstead has endeavored to transplant parathyroid glands which have been accidentally deprived of their vascular supply during strumectomy.

In a case of tetany following thyroidectomy a cure resulted from the implantation of two parathyroid bodies under the skin of the abdomen. The implants were obtained from two men operated on for goitre. (W. Davidson, "Beitr. z. klin. Chir.," lxvi, Hft. 1.)

V. INJECTIONS OF BOILING WATER. (Miles Porter, "Journ. A. M. A." July 12, 1913)

Any fairly large all-glass graduated syringe may be used. The glass barrel prevents one from injecting air; the more water the syringe holds the less rapidly will the water cool; the plunger and barrel being both of glass prevents binding or breaking due to unequal expansion. The needle ought to be long and rather fine.

Boil the syringe and needle in the water to be used for injection and keep the water boiling until the time of injection. When more than one injection is given at a treatment, reboil the syringe immediately before the next injection to insure having the water used as near the boiling point as possible.

Handle the syringe with long forceps (the points of which have been heated) and with sterile gauze or muslin. After cleaning the skin anesthetize it at the site of injection, with Schleich's solution. Avoiding any large superficial veins pass the long needle deeply into one lobe and inject the boiling water. Porter has used from 40 to 230 minims at one injection. Partly withdraw the needle and make another injection. With the long needle it may be possible to make two injections into each lobe and one into the isthmus through the same puncture. The discomfort produced by the treatment is usually slight and consists of a feeling of distension and of pain running up to the occiput. In some cases the pain has been severe. The goitre usually becomes larger and harder following the injection but later on decreases much. The improvement in symptoms is usually prompt and progressive for one or two weeks. The injections should be repeated at intervals of one or two weeks. The greatest number of injections given any one patient was eleven. Porter has used the treatment chiefly in three classes of cases; 1. Patient too sick to make a safe surgical risk. Cases

also of substernal goitre, the removal of which would be extra hazardous. 2. Patients with very mild symptoms. 3. When major surgical procedures have been refused.

The author has had no personal experience in the "boiling water" treatment of exophthalmic goitre, but Porter who devised it is a most reliable surgeon and his findings have been amply corroborated by others.

CHAPTER XXIX

THYMUS GLAND

An enlarged thymus gland may so press upon the trachea as to necessitate operation. Operation may be either exopexy with or without partial excision or it may be one of complete excision.

The thymus and thyroid glands being both branchiogenous organs may be simultaneously affected by the same influences. Thus the *cause* of Graves' disease may act on *both* these glands and the biochemical activity of each may have its effect on the production of the symptoms. Klose thinks that the fact that thyroidectomy only gives 70–80 per cent. of cures in Graves' disease, indicates that there is another source of toxin than the thyroid, viz., the thymus. (See H. Klose, "Chir. der Thymus-drüse. Ergeb. d. Chir.," viii, 1914.)

The work of Garré ("Zent. f. Chir.," Dec. 6, 1913) has demonstrated that the thymus *may* be responsible for the symptoms of Graves' disease. He reported the following case: Woman twenty-seven suffered for three months from marked Basedow's disease with severe diarrhœa. The trouble followed a gynecologic operation. The thyroid gland was scarcely enlarged; there was dulness over the manubrium sterni; lymphocytosis 46 per cent.; functionally increased vagotonus; negative adrenalin test; fall of leucocytosis to normal and marked increased elimination of nitrogen under a milk diet; increase of the symptoms after intramuscular injections of thymus extract. All these led Garré to remove the thymus. The results were excellent. The diarrhœa stopped at once. In six weeks the pulse rate dropped to below 100. The weight increased 19 pounds. The exophthalmos, sweating and tremor lessened. The blood picture remained unaltered.

v Haberer (German Surg. Congr., 1913) reported the case of a man suffering from exophthalmos, enlarged thyroid, violent and increasing tachycardia. Hemithyroidectomy did not benefit—neither did ligation of the vessels on the opposite side which was done two years later. When v. Haberer saw him his condition was precarious from dyspnœa and tachycardia. Immediate improvement followed thymectomy under local anesthesia, although the thymus itself proved to be very small. Four months after operation the patient was able to return to work and was free from dyspnœa, tachycardia and nervousness.

Since it is very difficult, even if possible, to define in which cases the thymus is the principal offender Klose recommends combined excision as the operation of choice in Basedow's disease especially in those cases in which fear of a "thymus death" formerly contraindicated operation. He claims (and is supported

by Enderlen and v. Haberer) that removal of part of the thymus makes the operation of strumectomy for exophthalmic goitre much less dangerous and distressing as well as giving better ultimate results.

Regarding the technique of the operation Klose writes, "It is possible in every case under local anesthesia to pull forwards the thymus bluntly after splitting the deep fascia and then to incise the capsule and enucleate the gland completely or in part. Experience has shown that complete removal is harmless in adults. The enucleation must of course be intracapsular. . . . v. Haberer urges that the posterior surface of the sternum be used as a guide in order to avoid trouble."

A. Exopexy.—Expose the upper part of the thymus gland by a median incision above the sternal notch. Pull the gland upwards and forwards. Anchor it with a few stitches to the fascia over the sternum. In the hands of Rehn, exopexy gave a good result. In a similar case Fritz König resected a portion of the gland, anchoring the remainder to the sternum, and obtained a cure of the dyspnœa.

B. Excision of the Enlarged Thymus. (Ehrhardt, "Archiv für klin. Chir. lxxviii, 602.)

Step 1.—Make a median incision from a point just below the larynx to a point about ½ inch below the upper edge of the sternum. Layer by layer divide the tissues, including the isthmus of the thyroid, until the trachea is fully exposed. At each expiration a large part of the thymus rolls forwards in the root of the neck.

Step 2.—Seize the thymus with forceps and pull it forwards. Enucleate the gland by blunt and sharp dissection attending to hemostasis at the same time. Partially tampon and close the wound.

Ehrhardt operated with success as above in one case.

Veau and Oliver ("Arch. de méd. des enfants," 1910, Nov.) operated in three cases in much the same manner using chloroform narcosis. After exposing the gland and fixing it with forceps they penetrated the capsule first on the left side and enucleated the gland, then they did the same on the right side, and closed the cavity with catgut sutures. Veau and Olivier performed total extirpation as above described without ill effect, but if one fears removal of the whole gland one may content oneself with the removal of one half. ("La Presse Méd.," ix, 1910.)

The surgeon must remember that the thymus gland may cause death from pressure without the presence of any visible or palpable tumor in the neck.

Chevalier Jackson ("Journ. Amer. Med. Assoc.," May 25, 1907) has demonstrated an enlarged thymus by means of the X-rays, and with the bronchoscope showed that pressure from the thymus produced scabbard deformity of the trachea. After tracheotomy Jackson measured the distance from the tracheotomy wound to a point 1 cm. from the bifurcation of the trachea and procured a tracheotomy cannula of this length. The use of a cannula passing through the constricted trachea notably facilitated the removal of the thymus.

PART II.—THE THORAX

CHAPTER XXX

OPERATIONS ON THE BREAST

Evacuation of Abscess by Incision.—The classical method of incising the breast to empty an abscess is exceedingly simple. Make an incision through the skin, beginning peripheral to the *areola*, along a line radiating from the nipple and situated over the inflammatory swelling. By combined sharp and blunt dissection penetrate the abscess, clean the cavity, and provide drainage. The object of radial incision is to avoid transverse and unnecessary division of glandular structures.

An abscess forming in the breast itself may break through to the subcutaneous or to the submammary areolar tissues. The communication between the primary focus and the secondary abscess may be narrow. Several foci of pus may be present and only communicate with each other through narrow passages. To effect drainage and avoid all deformity Morestin operates as follows:

From the base of the nipple to the edge of the areola (fortunately the areola is usually widespread in lactating women) make an incision through the skin. From this incision pass the knife subcutaneously into the superficial collection of pus. In withdrawing the knife enlarge the opening but do *not* cut through the skin beyond the areola. With a probe, forceps, or even the finger, explore the abscess and find the communication between it and the intramammary focus. With the knife enlarge this communication so that drainage will be free. If any other foci of pus are present penetrate them in similar fashion. Cleanse and antisepticize the abscess. Introduce drains and apply dressings.

No matter the site of the abscess, above, below, internal or external, the operation is the same. Bleeding is trivial and ceases spontaneously in a few minutes. Usually the drain may be removed in from three to five days and recovery ensues in ten to twelve days. The scar is hardly noticeable.

To avoid deformity from scars it has been suggested to use the principle of Thomas' operation for adenomata of the breast. Make a curved incision along the line of junction of the lower edge of the breast and the chest-wall. Penetrate to, but not through, the pectoral fascia. Separate the breast from the chest-wall until it is possible to gain access to the abscess from the deep surface of the gland. Evacuate the pus. Introduce one or two drainage-tubes into the cavity and bring their ends out through the wound. Replace the mamma on the thoracic wall. Partially close the skin-wound by sutures.

or dissect it out of its bed. Attend to hemostasis. Close the wound, with or without drainage.

Method B.—Thomas' operation has the great advantage of avoiding visible scars. It has been sufficiently described on page 271.

Excision of the Breast for Cancer.—A few years ago typical excision of the breast could be completed in a few minutes. The operation consisted in making an elliptical incision over the breast, including the nipple, in rapidly reflecting the skin from the gland, and in tearing and cutting the gland from the pectoral fascia. Through the wound the finger was pushed up into the corresponding axilla, and if any lymphatic glands were found enlarged, such were removed. The operation was primarily safe. The ultimate results were such that many experienced surgeons claimed recurrence always took place. Disgusted with the want of success attained, thoughtful operators became more radical and more successful. The typical operation no longer consisted in removal of the mamma and the axillary glands if they were palpably diseased, but the mamma, the pectoral fascia, the axillary glands, and fat were removed in one piece. The primary mortality of the operation did not increase perceptibly; the ultimate results were infinitely bettered.

The Operation.—The incision A, B, C (Fig. 397) is made through the skin. The ellipse between B and C includes the nipple and any portions of skin which may be adherent to the tumor. The skin-flap A B C E is reflected downwards well below the limits of the breast and to the posterior border of the axilla (*i.e.*, to the edge of the latissimus dorsi). The skin-flap A B C D is reflected upwards well above the limits of the breast and so as to expose the anterior boundary of the axilla. Beginning below the breast, one dissects from the pectoralis major, the fat of the chest-wall, the pectoral fascia, and with them the diseased mamma. This is continued to a point well above the breast, to the base of the skin-flap A B C D.

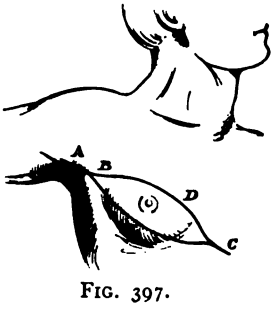


FIG. 397.

There is now a mass of fat, gland, and pectoral fascia *unconnected* with the chest-wall, but *continuous* with the fatty and lymphatic axillary contents. The chest wound is to be protected by an aseptic pad or towel and the surgeon attacks the axilla. Beginning on the *outer* or arm side of the axilla, its fatty contents are dissected from the vessels and nerve-trunks there situated. The first effort should be to dissect the axillary vein free from its fatty surroundings. Any axillary branches of the vein should be divided between two fine ligatures whenever found. When this dissection is being made, the arm should be kept as close to the body as is consistent with free access to the axilla; the object attained by doing so is that otherwise branches of the axillary vein would be put on the stretch and rendered unrecognizable, and further that in this position it is possible to retract the pectoralis major upwards, thus giving access to the apex of the axilla.

The contents of the axilla are easily separated from the posterior and internal walls of the space. If it is convenient to save the small nerves crossing the axilla, they may be preserved; but if, as is usually the case, time would be lost

in so doing, they should be sacrificed. The only connection left between the mass to be removed and the body is at the apex of the axilla. If the lymphatics higher up are believed to be healthy, this connection is divided and the excision is complete. If, on the other hand, it is suspected that the disease extends further, then the pectoralis major is divided and access is gained to the chain of lymphatics running up under the clavicle. These are removed in one piece with the tumor mass. The wound in the muscle is sutured. The whole wound is closed, axillary drainage being provided.

When the pectoral fascia is being removed from the pectoralis major, should any disease be found or suspected to exist in that muscle the whole muscle must be excised in one piece with the mamma.

Halsted has still further elaborated the operation, making it *tremendously* extensive and most remarkably successful. His success is so great that the author considers the Halsted operation or some modification thereof to be the preferable treatment for operable mammary cancer.

FIG. 398.—Halsted's incision.

Halsted Operation.—(The following description is compiled from Halsted's articles in the "Annals of Surgery," vol. xx, No. 5, and xxviii, No. 5.)

Principles of Operation.—The pectoralis major muscle, entire or all except its clavicular portion, should be excised in every case of cancer of the breast, because the operator is enabled thereby to remove in one piece all the suspected tissues. The suspected tissues should be removed in one piece.

Step 1.—The skin-incision is carried at once and everywhere through the fat (Fig. 398).

Step 2.—The triangular flap of skin A B C is reflected back to its base line, C A. There is nothing but skin in this flap. The fat which lined it is dissected back to the lower edge of the pectoralis major muscle, where it is continuous with the fat of the axilla.

Step 3.—The costal insertions of the pectoralis major are severed and the splitting of the muscle, usually between its clavicular and costal portions, is begun, and continued to a point about opposite the scalenus tubercle on the first rib.

Step 4.—At this point the clavicular portion of the pectoralis major and the skin overlying it are cut through hard up to the clavicle. This cut exposes the apex of the axilla.

Step 5.—The loose tissue under the clavicular portion of the pectoralis major is carefully dissected from this muscle as the latter is drawn upwards by a broad sharp retractor. This tissue is rich in lymphatics *and is sometimes infected with cancer.*

Step 6.—The splitting of the muscle is continued out to the humerus, and the part of the muscle to be removed is now cut through close to its humeral attachment.

Step 7.—The whole mass, skin, breast, areolar tissue, and fat, circumscribed

by the original skin incision, is raised up with some force, to put the submuscular fascia on the stretch as it is stripped from the thorax close to the ribs and pectoralis minor muscle. It is well to include the delicate sheath of the minor muscle when this is practicable. This step has been modified by Halsted in that he now ("Annals of Surgery," Nov., 1898) removes the pectoralis minor and exposes the subclavian vein at its inner part.

Step 8.—The axilla is now stripped of its contents and its anterior wall at one time, from within outwards and from above downwards. The axillary contents are dissected away with scrupulous care and with the sharpest possible knife. The axillary vein should be stripped absolutely clean. Not a particle of extraneous tissue should be included in the ligatures which are applied to the branches, sometimes very minute, of the axillary vessels. In liberating the vein from the tissue to be removed it is better to push the vein away from the tissues rather than, holding the vein, to push the tissue away from it. It may not be necessary, but it is well to expose the artery and remove the possibly infected tissue above it. It is best to err on the safe side and remove in all cases the loose tissue above the vessels and about the axillary plexus of nerves.

Step 9.—Having cleaned the vessels, we may proceed more rapidly to strip the axillary contents from the inner wall of the axilla—the lateral wall of the thorax.

Step 10.—When we have reached the junction of the posterior and lateral walls of the axilla, or a little sooner, an assistant takes hold of the triangular flap of skin and draws it outwards, to assist in spreading out the tissues which lie on the subscapularis, teres major, and latissimus dorsi muscles. The operator cleans the posterior wall of the axilla from within outwards. The subscapular vessels are exposed and caught before being divided. The subscapular nerves may or may not be removed.

Step 11.—Having passed these nerves, the operator has only to turn the mass back into its normal position and to sever its connection with the body of the patient by a stroke of the knife from B to C, repeating the first cut through the skin.

Step 12.—This step did not belong to Halsted's original operation, but has been added by him subsequently. Make a vertical incision parallel to and near the posterior margin of the sternomastoid muscle, dividing a few of the posterior fibres of the muscle. Expose the junction of the internal jugular and subclavian veins. Divide the omohyoid muscle at its tendinous part and draw its two bellies out of the way. Remove the supraclavicular fat by dissecting downwards and outwards from the venous junction, and the infraclavicular fat by dissecting from below. By elevating the shoulder the clavicle can be raised an inch or more away from the first rib when the operation is so far completed as to make this desirable. The web of fibrous tissue which binds the subclavian vein loosely to the clavicle is thus spread out and can be easily removed. The fingers can be passed from the supraclavicular to the infraclavicular and to the subscapular regions under the clavicle, and any fat in the latter region, near the internal or the posterior border of the scapula between the serratus magnus and subscapular muscles, which could not be well [illegible] can be drawn out through the neck.

Step 13.—Review the whole wound. Unite the divided omohyoid by a catgut suture. Close the wound in the neck. The edges of the chest wound are approximated by a buried purse-string suture of strong silk. Of the triangular flap of skin (A B C, Fig. 398) only the base is included in this suture. The rest of the flap is used as a lining for the fornix of the axilla. The axilla is never drained. The open wound remaining on the chest is immediately covered with Thiersch's skin-grafts.

Many surgeons, the author included, have devised almost identical operations for removal of the breast and have found such satisfactory.

Kocher's description of the operation is so excellent that it will be used as the basis of the following paragraphs. To Willy Meyer, however, belongs the credit

FIG. 399.—Kocher's incision.

FIG. 400.—(*Kocher.*)

of the radical breast operation in which the dissection of the lymphatics precedes the removal of the mamma. Meyer's operation was devised totally independently of Halsted's and was published during the same month as Halsted's.

Step 1.—With the knife make a few superficial scratches on the skin to mark out the line of incision which is shown in Fig. 399. From the clavicle to the edge of the anterior axillary fold near the insertion of the pectoralis major, complete the incision through the skin, subcutaneous tissue, and fascia. Expose the cephalic vein in the groove between the pectoralis major and deltoid, thus recognizing the upper edge of the pectoralis. Pass the finger around the pectoralis major one to two finger-breadths from the humerus. Guided by the finger, divide the pectoralis major.

Step 2.—The pectoralis minor now lies exposed to view. Divide this muscle near the coracoid process, and expose the great vessels and nerves of the axilla.

Step 3.—Beginning above, near the clavicle and coracoid process, dissect

the fat from the axillary vessels and nerves, and then dissect it free towards the thoracic wall. By this means the most difficult step of the operation is completed while the surgeon is fresh, without the annoyance of the loose mass of mamma, etc., getting in the way, as in the Halsted operation, and while the chest is still protected against chill by its fatty coverings, which will be removed later.

Step 4.—Complete the incision around the breast (Fig. 399). Excise the mamma, surrounding fat, and both pectoral muscles. The wound left is large (Fig. 400).

FIG. 401.—Skin incision. (*Meyer.*)

Step 5.—After attending to hemostasis, close the wound, as much as possible, by sliding the flaps together. Where the wound cannot be closed, cover it with Thiersch's skin-grafts. Provide for the axillary drainage by a tube introduced posteriorly.

After such extensive removal of important muscles one would naturally expect very serious loss of function, but such is not the case; the author has been assured by various patients that they are able to attend to their own housework and to dress their own hair satisfactorily.

In the "Jour. Am. Med. Assoc.," July 29, 1905, Willy Meyer published an excellent series of drawings illustrating his operation; these are so helpful that they are reproduced here without comment (Figs. 401 to 406).

FIG. 402.—Insertion of pectoralis major muscle exposed. (*Meyer.*)
Operator's left index finger encircling its tendon.

FIG. 403.—Finger under tendon of pectoralis minor muscle. (*Meyer.*)
Above, cut surface of clavicular portion of pectoralis major parallel to clavicle is visible. (In the belly of the pectoralis major is not so thoroughly detached from that of the pectoralis mi done here to show the latter's tendon.)

FIG. 404.—Subclavian and axillary veins fully exposed. (*Meyer.*)
glands and fat tissue not removed; smaller vessels still in connection with main trunks. Finger under fat towards sulcus bicipitalis, its nail resting on axillary vein.

FIG. 405.—Operative field, after removal of the mass. (*Meyer.*)
Stump of pectoralis minor muscle is visible.

FIG. 406.—Showing reformation of axilla. (*Meyer.*)

FIG. 407.—Jackson's incision. No. 1.

J. N. Jackson (Fig. 407), J. C. Warren and others have devised ingenious incisions for breast excision the only fault of some of these is that *perhaps* they may tempt the surgeon to sacrifice thoroughness of extirpation on the altar of æstheticism. In cases of cancer in the upper-outer quadrant where the skin between the breast and the axilla is under suspicion, Jackson's incision N°-2 ("Annals of Surg.," Aug., 1920) is valuable and permits of easy closure (Figs. 408 and 409).

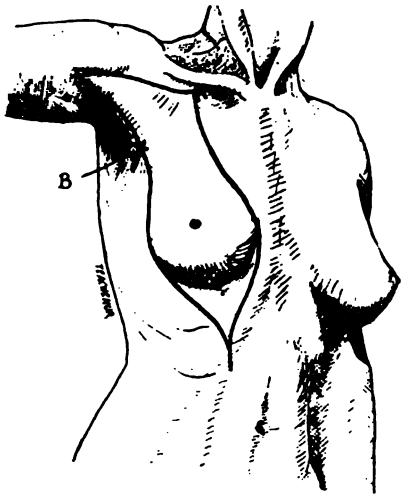


FIG. 408.—Jackson's Incision No. 2.

FIG. 409.—Jackson's Incision No. 2.

In about 16 per cent. of cases of breast cancer, diffusion of the disease and perilymphangitis cause obstruction of the lymphatics about the shoulder and lead to œdema of the arm. The consequent suffering is often atrocious and amputation has often been performed to give relief. Handley's operation of lymphangioplasty is of value in treating such a condition.

Francis Stewart's Operation (Trans. Arm. Surg. Soc., XXXIII, 1915).

Step 1.—From a point on the edge of the sternum remote from the growth and on a line with the nipple make a curved transverse incision skirting the upper margin of the breast and ending on the posterior axillary line *ABC* (Fig. 410). Undermine the skin upwards to the clavicle and the head of the humerus and from the sternum to the posterior axillary fold. This gives good access to the axilla.

Step 2.—Separate the clavicular from the costal portion of the pectoralis major and divide the tendon of the latter close to the humerus. Divide the insertion of the Pectoralis minor and clear the axilla of its contents in the usual fashion.

Step 3.—Join the ends of the original incision by a cut which skirts the lower

margin of the breast *ADC*, Fig. 410). Undermine the skin downwards to the edge of the costal arch or lower.

Step 5.—Remove the breast, pectoralis major and minor, etc. Attend to hemostasis.

The advantages claimed for the operation are free exposure of the subscapular space, avoidance of any scar running on to the arm, convenience of closure and of dressing.

Tansini's Operation.—(D'Este, "Rev. de Chir.," Feb., 1912.) Stiles has shown that the breast is a much larger organ than is apparent on ordinary inspection and palpation (see Fig. 411). There is constant prolongation of the breast upwards and outwards along the lower border of the pectoralis major which often reaches as far as the more anterior of the axillary lymphatic nodes Rieffel, Poirier and Charpy, v, 680).

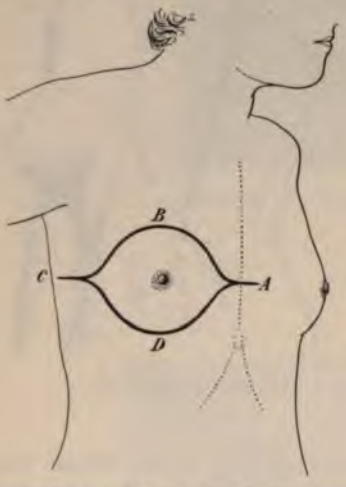


FIG. 410.—Stewart's Incision.

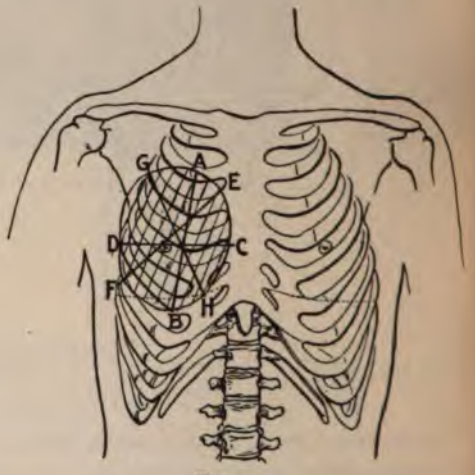


FIG. 411.

Every modern operation for cancer of the breast aims at the excision of the skin over the breast along with the breast, the tissues around it which might be involved and the lymphatic contents of the axilla. In none of the operations already described (Halsted's, Meyer's, Kocher's, Jackson's) except Jackson's No. 2, does the incision compel the removal of the skin overlying the axillary prolongation of the breast.

Tansini's method provides for very unusual and complete removal of the skin and for such convenient plastic repair of the wound that there is no temptation to skimp the extensive excision. The operation: *Step* 1.—Make the ovoid incision A B C D (Fig. 412) through the skin alone. This surrounds not merely the prominent mamma but the whole mammary region reaching medially (D) near or even onto the sternum, laterally (B) to the mid-axillary line, inferiorly (C) to the upper margin of the seventh rib and superiorly (A) to the summit of the axilla. Note that the skin between the breast and the axilla as well as most of the skin of the axilla itself is enclosed in the ovoid.

Step 2.—(a) Beginning at the lower external part of the ovoid (near B)

: the skin from the subcutaneous fat until the whole infra-axillary region is
d and the axillary border of the *latissimus dorsi* is reached. At this point
ate more deeply so as to expose the *serratus magnus* above and the upper
ions of the *external oblique* below. (If necessary remove the fascia cover-
ese muscles and some of their superficial fibres along with the mam-
mass.) Passing upwards and inwards separate the inferior and lateral
ments of the pectoralis major from the thoracic wall. Attend to
tasis.

In similar fashion dissect the skin downwards and inwards from the
incision until the desired limits from excision are reached. What are these
l limits? From a very thorough study Sampson, Handley (Cancer of the
: and Its Operative Treatment, p. 183) has come to very definite and rea-

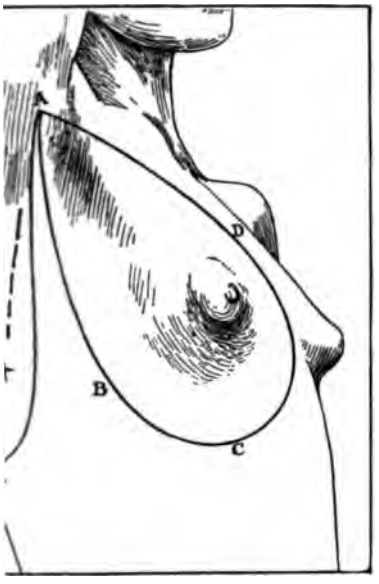


FIG. 412.—(*Rev. de Chir.*)

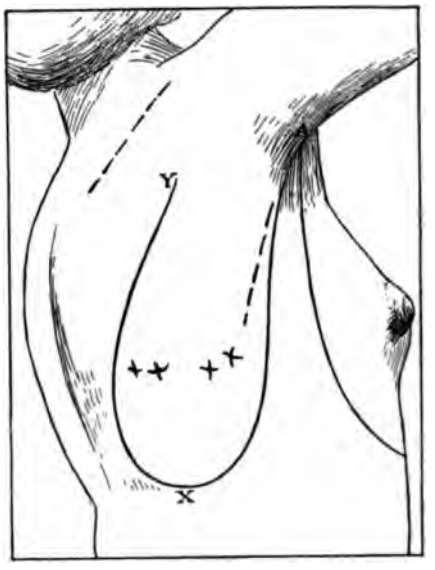


FIG. 413.—(*Rev. de Chir.*)

le conclusions. He writes, "The removal of a maximal circular area of
fascia centered upon the primary growth, is a step absolutely essential to
mpleteness of the operation, except in very early cases. There is no tech-
difficulty involved, if only the skin-flaps are sufficiently undermined, a
hose importance has been long emphasized by Mr. Stiles and by my friend
eacher, Mr. Jacobson, and one which is very thoroughly carried out in the
al practice of the Middlesex Hospital. It is a significant fact that the
tor, who has the best published operative results, lays stress on the removal
wide area of deep fascia, following the lines laid down by Stiles. Prof.
ne says: "* * * the skin incisions when made should not go straight down
e muscle. After the skin incisions have been mapped out, the skin and
ufficient fat to enable it to retain its vitality should be dissected up, and
uscular fibres should not be exposed till just below the clavicle above, be-
the middle line in front, over the origin of the abdominal muscles below,

and over the edge of the latissimus behind." It will be found that, judged by the standard I have set up—*i.e.*, the removal of a maximal area concentric with the growth—the area of deep fascia defined by Prof. Cheyne is very deficient in a downward direction, for the abdominal muscles arise well above the costal margin. The following measurements show the distance from the nipple to various points on the thorax in two patients with non-pendulous mammæ:

	Patient No. 1	Patient No. 2	Average
Nipple to tip of ensiform cartilage	4 in.	5 in.	4½ in.
Nipple to nearest point of clavicle	5 in.	6½ in.	5¾ in.
Nipple to nearest point of middle line	3½ in.	4½ in.	4 in.
Nipple to nearest point of edge of latissimus dorsi	.....	5 in.	5 in.

The distance from the nipple to the clavicle may be taken as the radius of the circle of deep fascia round the growth, which can, in practice, be removed without difficulty by undermining the skin flaps sufficiently and prolonging the incision somewhat in a downward direction.

If the growth starts under the nipple the deep fascia should accordingly be removed:

Above, up to the clavicle.
Internally, 1 to 2 inches beyond the middle line.
Externally, just beyond the anterior edge of the latissimus dorsi.
Below, to a horizontal line running 2 inches below the tip of the ensiform cartilage.

Coming now to growths situated near the margin of the breast, it is probable that the want of coincidence between the area of the present operation and the circle of infected fascia in these eccentric growths largely accounts for the bad prognosis associated with them.

The area of tissue removed should be concentric with the nipple only when the primary growth is situated just beneath that structure. If a cancer is situated at the sternal margin of the breast it may be necessary to excise the deep fascia beneath the inner half of the opposite breast. If the growth is situated at the lower margin of the breast it may be requisite to excise the abdominal deep fascia far down towards the umbilicus. If the growth is situated in the axillary tail of the mamma, the deep fascia will require excision in the deltoid region, and far backwards over the surface of the latissimus dorsi. Unless these considerations are borne in mind the growing edge of fascial permeation will be left behind at one point or another.

(c) Dissect upwards and towards the axilla the whole mass of breast fascia, fat and muscle which must be removed. Both pectoralis major and minor must be removed though sometimes the clavicular fibres of the former may be spared.

(d) While the mobilized mass containing the breast, etc., is supported by an assistant, clear the axilla of its fat and lymphatic tissue in the usual fashion. In doing this ligate and divide the external mammary (long thoracic) and acromio-thoracic vessels, but save the subscapular vessels as they are essential to the nutrition of the flaps to be used in the plastic repair of the enormous

ıded area of chest. Clear the fat from the infra-clavicular fossa. Along
the axillary fat remove the fat and cellular tissue lying between the
ula and the thoracic wall. Remember that all these tissues from the
rscapulo-thoracic space, the axilla, the infra-clavicular fossa and the chest-
must be removed in one piece. Attend to hemostasis. Cover the whole
nd with warm dressings.

Step 3.—(a) Place the patient in the lateral posture or midway between the
ral and ventral postures. Have the arm held somewhat elevated and
ucted. Recognize the spine, the axillary border and the inferior angle of

FIG. 414.—(*Rev. de Chir.*)

FIG. 415.—(*Rev. de Chir.*)

scapula. Outline the flap A X Y (Figs. 412 and 413). The pedicle of
flap should be 7–8 cm. (2¾–3⅛ in.) in diameter. The incision pene-
es the skin, the subcutaneous tissue and the latissmus dorsi (as soon as that
cle is encountered). Reflect the flap of skin, latissimus dorsi, teres major
a portion of the infra-spinatus. In separating these last two muscles from
scapula be careful to hug the bone, otherwise their nutrient arteries will be
ded and disaster invited.

[redacted] flap of skin lying between it [redacted] flap forward [redacted] With the [redacted] are left cover[ed] [redacted]

[redacted] recurrence. Handley puts [redacted] excision, has 11 per cent. [redacted] more fascia than Halsted [redacted] Lenhartz reported the following [redacted]

[redacted]	Apparently well three years after operation
[redacted]	9.4 per cent.
[redacted]	10.6 per cent.
[redacted]	34.8 per cent.
[redacted]	46.5 per cent.

[redacted] 70 per cent. were [redacted] 1895 to 1905 only 10 per [redacted] metastatic. The apparent [redacted] due to the absence [redacted] enough to exhibit [redacted]

[redacted] IN THE CHEST

[redacted] PLEURÆ

[redacted] the result of stabs, bullet [redacted] and surgical operations. The [redacted] above all infection. The [redacted] owing to pulmonary retraction [redacted] vessels lose their normal support [redacted] and act in an inefficient fashion. [redacted] the impression that the visceral and parietal [redacted] by atmospheric pressure: that puncture [redacted] produces pneumothorax and more or less complete [redacted] of the lung. This teaching has dominated surgery to too [redacted] Briefly atmospheric pressure is a very great factor in [redacted] application of the pleuræ but, as Macewen has shown, a large flap of the chest wall, including the parietal pleura, may be lifted up, exposing a corresponding surface of lung without pulmonary collapse. The failure

collapse is due to molecular adhesion between the two pleuræ aided by the istence between them of a thin layer of serous fluid, *i.e.*, the apposed surfaces pleura are moist. If the finger is passed around the wound and separates the iceral from the parietal pleura air enters and a certain amount of collapse curs, but if the elastic chest wall is pressed inwards so that the parietal pleura allowed to come once more into free contact with the visceral, then the lung ain expands. These remarks of course apply only to the healthy pleura, as a pleura roughened by ridges and masses of exudates conditions are entirely ferent.

The above principles and observations of Macewen's were the basis of suc- sful treatment in a number of serious wounds reported by him. ("Brit. Med. rn.," July 7, 1906.)

Elsberg ("Med. Record," May 23, 1908) finds that the weight of the heart lls it backwards and makes tense the pleural covering of the anterior medi- inum when the patient is in the dorsal decubitus and thus prediposes to eumothorax when the pleura is wounded. If the patient is placed in the ntral position pneumothorax is much less likely to arise. Lilienthal has plied Elsberg's findings with success in twenty-one cases in which the pleural rity was opened and no interference with the mechanism of respiration re- ted. [Lilienthal's cases comprised a number of empyemas, two liver ab- sses, five subphrenic abscesses and one left-sided bronchiectasis.]

Methods of Keeping up Respiration when the Thorax is Freely Opened.—I. For ny years the French have insisted that special means for keeping up respira- n are entirely unnecessary, and their experience during the Great War up- lds them. Pierre Duval writes (Surg., Gyn. and Obst., Jan. 7, 1919) "Com- ete pneumothorax is not associated with any particular danger, and, indeed, is necessary for the manipulation of the lung. Complete pneumothorax does t cause any respiratory trouble or increase of arterial pressure, and causes s shock than a laparotomy." The French practice of making a wide opening the chest allows any manipulation of the lung without danger.

Morris H. Clark (personal communication) agrees absolutely with the rench view. He uses gas oxygen anesthesia with the Connell apparatus ex- tly as if the thorax was uninjured and has not encountered any trouble which uld conceivably have been lessened by the employment of differential or tratracheal apparatus. If the surgeon desires any special inflation of the ng, *e.g.*, when the last sutures are being tied it is easy to produce any degree f such by applying the face piece more firmly and either increasing the inflow f the combined gases or decreasing the outflow from the mask.

II. Mechanical and *according to the French view*, unnecessary means of eeping up respiration during operation. Many believe that when one side of he thorax is freely opened respiration becomes much embarrassed; when oth sides are freely opened it becomes impossible under ordinary circum- tances. Matas and a number of others devised more or less complicated means y which air from a bellows, or its equivalent, could be pumped through the nose, he mouth or a tracheal cannula alternately into and out from the lungs ("Trans. m. Surg. Assoc.," vol. xix). Richter ("Surg., Gyn., Obstet.," Nov., 1908) odified the pump method. In his apparatus the necessary air is stored in a

tank under high pressure. As required, air is conducted from the tank to a rubber balloon where it can be kept at a moderate pressure. From the balloon the air is led through a rubber tube to a tracheal cannula and so into the lungs. An ingenious and simple electric valve permits air to flow into the lungs at proper and regulated intervals, and between these intervals permits it to escape. Another device permits the administration of an anesthetic. Richter demonstrated his method to the members of the Society of Clinical Surgery. Meltzer and Auer have described a method of artificial respiration which they name "respiration by the continuous intratracheal insufflation of air." A small tube is passed through the larynx into the trachea almost to the bifurcation, and by means of a foot-bellows or electric motor air mixed with ether is blown continuously through the tube under pressure of 15 or 20 mm. of mercury. The lungs are kept moderately distended, the blood is aerated and the excess air escapes alongside the tube. The method has been used successfully by Carrel and Elsberg ("Annals Surg.," July, 1910) in many operations on the thoracic viscera. The author has used the Meltzer-Auer method in experimental work on rabbits, using instead of the foot-bellows a simple hydrostatic air compressor extemporized by Sutton. Elsberg suggests: "the tube that is to be introduced into the trachea should be a fairly rigid one of rubber with an opening at its lower end. It should be as long as an ordinary stomach-tube. Tubes of various sizes should be kept on hand. The tube to be used in a given case should fill up about one-half of the lumen of the trachea. One can obtain a sufficiently accurate idea of the size to be used by estimating the diameter of the trachea at the foot of the neck." Lilienthal and Elsberg have applied the method successfully in the human being.

Lilienthal is no convert to the French view. He considers that the mediastinum can be so steadied by traction on the lung during operations on certain war wounds that ordinary exploration and removal of foreign bodies can be safely accomplished without any form of differential pressure. The same is true in old infected conditions. In all other forms of thoracic surgery including full exploration of the thorax in trauma, in resection of lobes and in operations upon the œsophagus or other intrathoracic organs, he is convinced that the omission of some form of differential pressure will greatly jeopardize the patient. The apparatus is most simple. If ether is used it is put in a suitable bottle with two short tubes penetrating the stopper but not extending below the surface of the ether. A foot bellows or even a Paquelin bulb suffices to furnish the current of air. A tube (about Fr. 14) leads from the bottle to the patient, and should be marked $3\frac{1}{2}$ inches from its distal end. The tube is introduced into one nostril not further than the mark. If Nitrous Oxide Oxygen is used, no bellows is required, the force of the current being regulated by means of a stop-cock, and the gas passes through a wash bottle.

Albert Ehrenfried ("Boston Med. and Surg. Journ.," April 13, 1911) endeavored to construct a simple, portable apparatus independent of electric currents, etc., by which ether might be administered according to the Meltzer-Auer method.

The apparatus (Fig. 416) "consists of a Wolff bottle with three necks, sitting within a copper water jacket, and a foot-bellows. By means of the cocks on the

outside of the jacket, the stream of air from the bellows can be carried through the hot water, over the top of the ether (contained in the Wolff bottle), or through the ether when a particularly strong vapor is desired. Air and ether vapor may be mixed in any proportion. Connected with the delivery end of the apparatus is a safety valve and pressure regulator consisting of a bottle of mercury into which a tube is plunged. The depth of the tube in the mercury, which is adjustable, represents the maximum of pressure which is allowed within the apparatus; if for any reason, such as a spasm of the glottis, the pressure should rise, the valve "blows off" automatically and danger from interstitial emphysema is avoided. In our early experience we employed a dial manometre, registering in millimetres of mercury, to record the pressure, but we have found

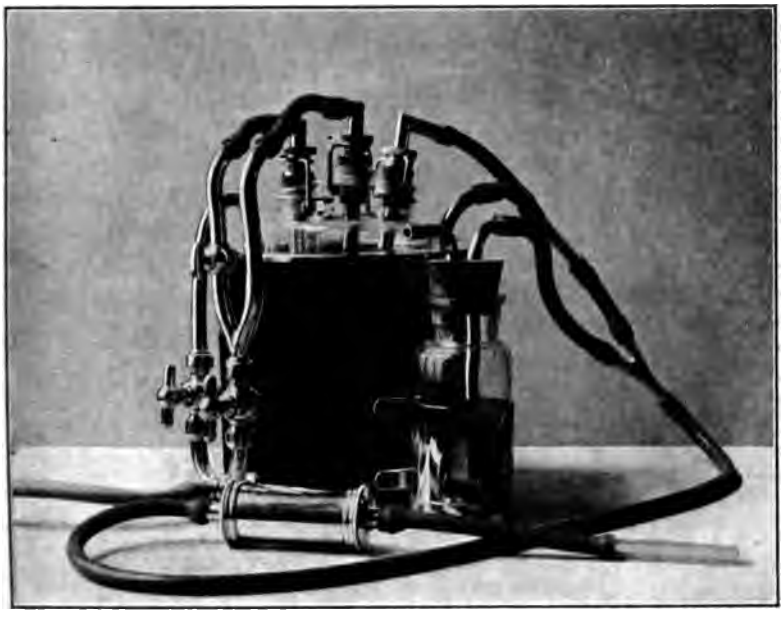


FIG. 416.—Ehrenfried's intratracheal etherization apparatus.

that the pressure bottle answers as well for all practical purposes. The apparatus is provided with a device to prevent droplets of condensed ether being carried into the larynx. The air or mixture is supplied at a practically constant temperature of about ten degrees above room temperature, if the operation is to last over half or three-quarters of an hour, the contents of the water jacket should be replaced. The air supplied may be filtered and moistened. For an intratracheal tube we use a French lisle catheter, 22 to 24 F., moistened in hot water to render it pliable, a new and sterile one for each case. Soft rubber tubes have the advantage of standing sterilization by boiling better, but they are less easy to introduce. The chief difficulty with this method of anæsthesia so far has been the introduction of the tube. We now use a simple introducer, a laryngeal forceps with sleeves attached for grasping the tube near its extremity, similar in principle to the introducer of Doyen. After considerable pains to produce the proper curve—working on frozen sections and cadavers—we have made an in-

strument, Fig. 417, which can be guided into the larynx in a matter of seconds, with the mouth-gag in place and the left forefinger on the epiglottis, without the necessity of using a head mirror or electric illumination, or changing the patient on the table to and from the Rose position, as is necessary with the direct laryngoscope."

Samuel Robinson (" Surg., Gyn., Obstet.," May, 1912) describes his apparatus by which ether may be administered by insufflation. He uses as the intratracheal tube a soft-rubber catheter introduced by means of Cotton's introducer, Fig. 418. With the same apparatus positive pressure may be obtained by the mask method (Robinson's mask or Habberley's intrabuccal clamp). Robinson devised a positive and negative pressure cabinet, but finds cabinets cumbersome, expensive and possessing no advantage over the mask.

Danis ("La Presse Méd.," Dec. 25, 1912) describes an hyper-pressure apparatus very similar to Robinson's which has been used successfully by Lambotte. The use of positive pressure by any mask method appeared to the author to be dangerous on account of vomiting, but Robinson remarks that "its temporary removal in case of such unusual emergencies as vomiting and instrumentation has not been found to interfere with its successful employment."

FIG. 417.—Ehrenfried's introducing forceps.

FIG. 418.—Ehrenfried's modification of Cotton-Boothly introducing cannula.

Sauerbruch was the first to devise a cabinet by means of which the thorax could be freely opened and respiration kept up under the force of either negative or positive pressure. Brauer constructed a rather clumsy apparatus for keeping up respiration under positive pressure. Willy Meyer and his brother (an engineer) have constructed a very efficient cabinet for both negative and positive pressures. It would be out of place to describe here the structure and methods for the employment of any of the pneumatic cabinets, each of which has its advantages and disadvantages; it will be sufficient to give the principles on which they work.

Negative Pressure Cabinet.—The surgeon, his assistants and the patient's body are inside the cabinet. The patient's head protrudes through a hole in the wall of the cabinet, his neck being surrounded by an air-tight collar. By means of an air pump, controlled by a manometre, the air pressure inside the cabinet is lowered sufficiently to permit of respiration after the thorax is opened.

Positive Pressure Cabinet.—Same as negative pressure cabinet except that the patient's body is outside while his head and the anesthetist are inside the cabinet. By means of an air pump the pressure of the air inside the cabinet is increased.

A. Treatment of Wounds Penetrating the Chest.—Treatment of wounds etrating the chest varies, (*a*) with the character of the wound, (*b*) with the oundings of the patient and the facilities for operating and giving post- rative care, (*c*) with the ideals and of course with the technical skill of the geon.

A bad sucking wound* causes terrible respiratory and cardiac distress and t be occluded in one way or another at once. If the circumstances permit, occlusion should be effected by a formal and definite surgical operation ined to obviate infection and late complications but first of all to save life. The ideals of some surgeons are to provide immediate safety hoping that d fortune will ward off complications or if complications arise that they may remedied later. Other surgeons having their eyes fixed on the late results ve after perfection and, theoretically at least, operate freely on every chest and. On closer examination of the actual work of the latter class of surgeons vill be found that they commonly mix their theoretical ideals with common se and modify their conduct accordingly.

G. E. Gask (Brit. Med. J., April 12, 1919) points out that in war the deaths m chest wounds in patients who have been brought off the field occur in sualty Clearing Stations (Evacuation Hospitals) within a few hours, from e severity of the wound, shock and hemorrhage, or after two or three days m sepsis. In Base Hospitals the deaths are all from sepsis. The sources of fection are (*a*) missiles, clothing, splinters of bone, etc., (*b*) sucking wounds hich always suck in infection, (*c*) an infected parietal wound from which in- ction spreads inwards by continuity finding a suitable field for growth in a mothorax, (*d*) a foreign body in the lung. His indications for operation are) Ragged wound of soft parts, (*b*) compound fracture of the ribs, (*c*) continued eeding internal or external. (*d*) Suction of air into thorax (open thorax), (*e*) tention of large foreign body, (*f*) pain out of proportion to the apparent verity of the wound; often this is due to an in-driven splinter of bone. (*g*) apidly increasing pneumothorax due to a valvular opening into the pleura alvular pneumothorax).

Gask recommends operating as soon as possible after recovery from initial ock.

There will almost always be a great difference between the wounds of civil e and those so common in war. Fragments of shells, rocks, bone, clothing d dirt of all kinds from the highly fertilized fields of France driven into the orax rendered the chest wounds of the Great War much more dangerous than e injuries common in civil life and yet from the more serious wounds great sons may be learned regarding the care of the less serious.

In any serious chest wound an opiate is essential. Rest is obligatory. Do t let the patient lie on the healthy side as to do so interferes with the respira- ry movement of that part of the chest and also favors the entrance of air to the wound and conduces to separation of the two layers of the wounded ura. Exercise pressure on the injured side of the chest and if necessary on

*A sucking wound is one in which the opening in the pleura is large enough to admit by suction in quantities as great or greater than that which enters the lung through larynx.

the hypochondrium to support the diaphragm. If a sucking wound is present occlude it with a moist pad until it can be properly treated.

Clean-cut stab wounds of the chest may generally be treated "expectantly," any complications being attended to as they arise. Most wounds of the chest wall ought to be explored and devitalized tissues and foreign bodies removed, in fact the classical "debridement" ought to be carried out. If one or more ribs are injured their jagged ends should be pared and smoothed. If the pleura has been opened and there is no evident injury to the lung or intrapleural bleeding the pleural wound ought to be closed at once. Often closure of the pleura alone is impossible, if this is so the sutures must include muscle as well, or even pericostal sutures may be employed.

Through and through gunshot wounds may generally be left alone except for debridement of the superficial wounds. Except in very severe wounds of the chest wall any hemorrhage into the pleura usually comes from the lung and not from the intercostal vessels. Hemorrhage into the closed pleura is either fatal very promptly or not at all (except from infection); it practically never kills after 72 hours.

If blood effused into the closed pleura remains sterile and is in quantity, clot deposited on the visceral layer very rapidly becomes tough, compresses the lung and prevents expansion. Later organization of the clot makes the compression permanent. When the blood is chiefly fluid and there is little clot, aspiration may be done on the second or third day with little or no danger of the hemorrhage recurring and usually leads to cure.

As the diaphragm occupies an abnormally high position in hemothorax exploratory aspiration should be done high up and not low as when for ordinary pleural effusion.

When the quantity of blood is small even if the proportion of clot is considerable, aspiration suffices, as the area of lung compressed is so small that the patient by exercise so aids thoracic movements that the clot becomes absorbed. If the hemothorax is large and several aspirations fail to produce recovery there is excess of clot and thoracotomy with removal of the clot is obligatory. Should the thoracotomy be too long delayed and the clot become organized, then decortication or its equivalent, viz. criss-cross incisions through the layer of scar tissue imprisoning the lung, should be practiced. After treating the hemothorax close the chest wall without drainage. If an infected hemothorax is seen early, Gask advises major thoracotomy, cleansing of the cavity and closure of the chest. He remarks that drainage of the chest is like amputation of a limb, sometimes necessary but still a surgical failure.

When the lung is much lacerated or gross masses of foreign bodies are driven into it and are easily located thoracotomy is necessary. This may be done by resection of a long segment of rib, preferably the fourth rib, from the mid-clavicular to the posterior axillary line (Lockwood, War Med., August, 1918.) A rib spreader aids in giving good access.

Lilienthal (Journ. A. M. A., March 22, 1919) prefers intercostal thoracotomy, making a long intercostal incision usually in the seventh interspace and separating the ribs from 3 to 5 inches by means of a powerful retractor. When the injured lung is exposed, he seizes and brings it into the wound. As soon as the

ng is stabilized by pulling on it in this purposeful fashion any dangerous ediastinal flapping ceases.

Wounds of the lung should be treated by excising evidently devitalized ssues and closing the wound with sutures. Closure of the visceral pleura is ry important.

If typical debridement is impossible because the wound is a tunnel, Gask Brit. Med. J., April 12, 1919) recommends cleaning the tunnel with gauze ad suturing the ends of the tunnel. If, as is *uncommon*, an open bronchus found at operation it should be crushed and ligated with catgut. Remove l clots and foreign bodies from the pleural cavity with instruments and by abbing with moist gauze. Just before closing the chest, systematically ab the *whole* of the pleural cavity both visceral and parietal surfaces with uze wrung dry out of hot saline solution and then with gauze wrung out of rmed ether.

Close the chest completely with sutures.

If there is much gaping of the parietal pleural wound the lung may be sutured [illegible] and the muscles sutured over the gap thus filled. The skin wound should be carefully closed.

Before closing the thoracic wound Brewer (Personal communication) some- [illegible] guard by the hand inside the chest, rapidly incises the skin and resects [illegible] segment of a rib at a place suitable for drainage but does not penetrate [illegible] pleura costalis. The object of this trivial procedure is that should it later [illegible] necessary to open the pleura it can be done without an anesthetic and [illegible] without enlarging the real thoracotomy incision.

[illegible] recommends that "Injuries of the heart or pericardium [illegible] by a paramedial flap of the fourth and fifth, or the fifth [illegible] costal cartilages depending on the position of the heart. The [illegible] rapidly and this route is ample, gives free access [illegible]

[illegible]

[illegible]

[

nent. If the lung wound remains open, *e.g.*, from its size, from a shred of visceral pleura being pushed into it, etc., the symptoms will promptly recur and operation becomes urgent.

(*b*) Expose the fractured rib or ribs by incision; excise enough of one or more ribs to gain access to the wound in the lung. Keep up pressure on the thoracic wall. An advantage of incomplete or of no anæsthesia is that the patient may be made to cough, sneeze, struggle, etc., and so force the lung towards the wound. Treat the wound exactly as in the case of a stab wound.

C. Emphysema Resulting from a Fractured Rib.—The emphysema may or may not be accompanied by marked pneumothorax. Macewen (*loc. cit.*) has shown that the emphysema results from the lung tissue being hooked on to the spiculæ at the fractured end of the rib and a free path being established between the injured lung and the lacerated subcutaneous tissues. Logically the operative treatment is identical with that for any other lung wound.

OPERATIONS ON THE PLEURAL CAVITY

Empyema resulting from infected wounds and from disease of ribs, etc., calls for early operation first to treat the primary condition and second to treat the empyema.

When empyema is an accident or epiphenomenon in the course of acute pulmonary infections early radical operation is very objectionable.

Operation should never be adopted before the twelfth day of the disease and only exceptionally as early as that (Dodge).

During the early stages the exudation is sero-fibrinous in broncho-pneumonia associated with hemolytic streptococci. If this exudation is causing distress it may be removed by aspiration, repeated as may be necessary. Some recommend that oxygen or filtered air be introduced to take the place of the fluid removed. When the pulmonary lesions are well or nearly well and the symptoms of slight dyspnoea with neither cyanosis nor bloody expectoration are in direct proportion to the amount of fluid in the pleura, then a cutting operation promises much and is obligatory. A respiratory rate of 45 to 50 per minute accompanied by notable cyanosis, oliguria and circulatory disturbances usually contraindicates operation as the pulmonary trouble is the real criminal and the pleuritic is of minor importance. In other words, if the pleural effusion, whether it be sero-fibrinous or purulent, is merely a concomitant of a general acute infection, operation is wrong until the primary and more serious trouble is overcome when operation may become not merely beneficial but imperative.

In ordinary pneumococcic pneumonia empyema as a complication is usually late and the pulmonary condition may well permit of its early drainage. Aspiration by itself is sometimes curative in such cases especially in children.

Exploratory Puncture.—The existence of fluid in the pleural cavity is diagnosed or suspected; by exploratory puncture its presence and character are determined. Choose a point on the chest-wall corresponding to the location of the suspected fluid. Fluoroscopy is often of great value in locating the fluid. Clean the skin thoroughly. Choose a hypodermic syringe with a long and not

too fine needle and sterilize them. Insert the needle into the pleural cavity at a point just *above* a rib. This avoids danger of injuring the intercostal vessels. Slowly withdraw the piston of the syringe. If fluid is found, preserve it for examination; if it is not found, the operation should be repeated at several points and the needle examined after each withdrawal lest it should have become plugged. No dressings are required.

Thoracentesis.—The object of the operation is the removal of fluid from the pleural cavity. The operation may be: (*a*) *Exploratory*. The fluid withdrawn is examined microscopically. If tuberculosis is suspected, the examination should include the inoculation of guinea-pigs. (*b*) *Therapeutic*. In adults when the fluid is not infected the operation is curative. In children even when the fluid is infected a cure often results.

Strict asepsis must be maintained otherwise a simple effusion into the pleural cavity may be converted into an empyema, or to the bacteria which have already produced an empyema there may be added others which may markedly increase the intensity and gravity of the disease. The patient should be placed in a semi-erect posture, if necessary being propped up with pillows. If he is weak, give him a stimulant of strychnine or alcohol.

The favorite points for operation are the eighth intercostal space near the angle of the scapula and the sixth near the midaxillary line. Remember that in hemothorax the fluid is usually at a higher level than in hydro- or pyothorax. Clean the patient's skin. If desired, inject a few drops of a 2 per cent. solution of novocaine or procaine into the skin at a point over the rib near its upper edge. With a fine knife make a puncture through the skin at this point. Pull the skin-wound upwards so that the needle of a Potain aspirator (thoroughly disinfected) can now be introduced and made to pass into the chest in contact or nearly so with the upper edge of the rib. The object of puncturing the skin with the knife is that, the skin being tough, so much force is required to push the aspirating needle through it that, the skin once passed, the needle is liable to be jerked into the tissues. Another reason is that disinfection of the deep layers of the skin being practically impossible, the needle cutting its way through may conceivably become infected and do harm.

In whatever way the skin is penetrated, the puncture through it should not be opposite that through the deep structures; a valvular wound is desired. The needle is made to hug the upper edge of a rib so as to avoid injuring intercostal vessels. Having introduced the needle, aspiration is begun. If fluid does not come, this may be due to the needle having become clogged with tissue or a clot of fibrinous material. A stillette passed through the needle will free its lumen. If obstruction to the lumen is not the cause of failure to obtain fluid, the needle should be *partially* withdrawn and reintroduced in another direction. Working, as one does, in the dark, several punctures may be necessary before the fluid is found or one is satisfied that it is absent. Another cause of failure is discussed under the name "pleurisy blocqueés."

When the fluid flows, let it flow slowly. If the patient coughs or has a feeling of oppression, stop the flow until he recovers. The same must be done if the pulse alters markedly or the patient becomes faint. As the fluid escapes the patient may be lowered in his bed. If the effusion is great, it is wise to stop

the operation before the fluid is nearly all removed. The remainder may be absorbed. The sudden complete emptying of the sac is likely to do harm.

Morriston Davies (Lancet, Dec. 28, 1912; Brit. Med. Jr., April 25, 1914) finding it impossible to remove any appreciable quantity of pleuritic fluid, especially in cases where its presence would interfere with skiagraphy of the lungs, has overcome all difficulties by replacing the abstracted fluid through the introduction of oxygen. He draws off the fluid by an aspirator in the usual manner but as soon as the first symptoms of drag on the intrathoracic organs are noticed, viz., discomfort, pain or cough, he permits about 100 c.c. of oxygen to flow into the chest through a needle introduced two or three interspaces above the aspirating needle. The two processes of aspiration and oxygen replacement are alternated until all the fluid is removed. The apparatus used for nitrogen pneumothorax acts admirably for the introduction of the oxygen.

Kenneth Mackenzie (Trans. Am. Surg. Assoc., 1914) uses warm sterile liquid paraffin instead of the oxygen. His technique seems unnecessarily elaborate but promises well. When it can be demonstrated that no more pus is forming the paraffin may be withdrawn very gradually—only two or four ounces being removed at a time at intervals of two or three days governed by X-ray examination until the pleura is free and occupied by a completely expanded lung.

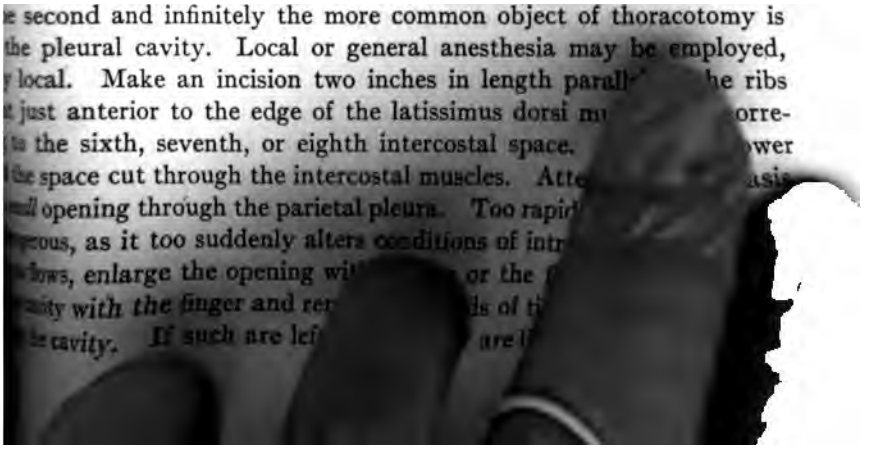
Pleurisy Blocquées.—Occasionally all the physical signs of fluid being in the pleura are present, the aspirating needle is inserted but no fluid flows. Examination of the needle shows no plugging of its lumen. Dufour, in 1905, showed that old pleuritic effusions exist which cannot be aspirated by ordinary means while Mosny and Stern ("La Presse Méd.," Dec. 11, 1909) demonstrated the same regarding recent acute pleurisies. The reason for the failure of aspiration is that the fluid happens to be in a cavity with rigid walls, *e.g.*, a cavity whose wall may consist of hepatized lung, the chest-wall and pleuritic adhesions. If, as occasionally happens, the tension of the fluid is about equal to that of the atmosphere, then only a small amount of the fluid-will escape through the aspirating needle; if the tension of the fluid is less than that of the atmosphere, no fluid will escape. If a second hollow needle is passed alongside the aspirating needle, atmospheric air will be admitted into the cavity and aspiration becomes easy.

Thoracotomy.—The objects to be attained by thoracotomy are:

I. Exploration and the performance of various operations by the transpleural route. For this purpose a long intercostal incision is excellent. Make a very long incision in an intercostal space down to but not through the pleura. Open the pleura in the same manner as the peritoneum is opened in laparotomy. Le Fort (Rev. de Chir., May and June, 1917) insists that the pleura be opened widely, that collapse of the lung against the vertebræ is a fable only occurring in cadavera, that a small pleural opening is dangerous as it may occasion a condition identical to valvular pneumothorax. After the pleura is opened Carrel's technique may be used (Trans. Am. Surg. Assoc., 1914, p. 452). "The operating field was walled off by two kinds of towels. The first kind was made of Japanese silk which had been previously boiled in water, dried, and sterilized in the autoclave, like ordinary pieces of dressing. The second kind of towel was composed of absorbent cotton and of black Japanese silk. These towels were

he following way: Two pieces of fine black Japanese silk were sewed
t the edges. Between these two pieces was placed a layer of absorbent
out 1 cm. thick, and the whole towel was knotted throughout, thus
pad. These towels were sterilized in the autoclave. Both kinds of
ve described were used for walling off the operating field. When the
the superficial part of the thoracic wall was completed and the hemo-
ired, the pleural cavity was opened by means of a small incision made
idle of the intercostal space. A dry, white Japanese silk towel was
l into one end of the incision, while a second one was introduced at the
. These towels afterward served as a protection to the anterior and
arts of the pleural cavity. Next, the incision of the thoracic wall was
l and the thoracic cavity was opened wide, the lungs being meanwhile
y protected by the towels already introduced. Immediately after
lack silk and cotton-padded towels were laid on the upper and lower
he wound and introduced into the cavity in such a manner that they
ly protected the upper and lower parts of the pleura. Next, a Gosset
vas applied and the edges of the wound were retracted as much as was
for the purpose of the operation. The edges of the padded towels
ged in such a way as to circumscribe the operating field and to leave
exposed to the air and to the sight of the operator. Additional
wels could be used afterward, if necessary, in order to secure a more
walling off of the operating field. By means of this procedure the
ity appeared to be almost completely protected against the infection
by the atmospheric germs as well as against all possible infection or
caused by the handling of the serous membrane by the hands of the
by the rough sponging with gauze, and by other operative trauma-
oreover, when hemorrhage occurred the blood was prevented from
to other parts of the thoracic cavity."

iedrich, Sauerbruch, de Quervain or Lilienthal self-retaining retractors
aders serve well to open the wound widely. After completing the
close the wound by interrupted buried sutures each of which sur-
rib above and below the intercostal wound (pericostal sutures). As
these sutures is being tied have the anesthetist cause the lung to
as to drive all air out of the pleural cavity or aspirate the air from the
Nitzel has filled the pleura with boracic acid solution, closed the
d then removed the solution by aspiration.


e second and infinitely the more common object of thoracotomy is
the pleural cavity. Local or general anesthesia may be employed,
local. Make an incision two inches in length parall
just anterior to the edge of the latissimus dorsi m
the sixth, seventh, or eighth intercostal space.
space cut through the intercostal muscles. Atte
opening through the parietal pleura. Too rapi
ous, as it too suddenly alters conditions of intr
ows, enlarge the opening wi
ity with the finger and re
cavity. If such are le

drainage and delay recovery. Drain by means of tubes passed into the p cavity. Not much of the tube should project into the pleura. The may be rigid or soft. To prevent the tube slipping into the pleura either it to the skin or transfix it with a large safety-pin or both. If necessary (it is necessary), partially close the skin-wound with sutures. Surround the end of the drain with sterile gauze in bird-nest fashion. This prevents pressure on the tube. Apply abundant dressings. Some surgeons oiled silk over the mouth of the drainage-tube to act as a valve, allowi escape but not the entrance of air into the pleura. This is unnecessary. the pleura has been penetrated, a counteropening may seem desirable make this, pass a forceps through the wound, through the cavity, and its point elevate the tissues at the position selected. Cut down on the f and push them through the new wound. Grasp a perforated rubber tu the jaws of the forceps and pull the tube through the cavity. This pr efficient through-and-through drainage. Ochsner is a great advoca through-and-through drainage. If at any time it is desired to withdra tube and introduce another, fasten a thread to the end of it and in withdr the tube pull the thread through the c with this thread *in situ* it is easy to intr another tube. Later the tube may be re by a few strands of silkworm-gut. Tu drainage must be kept up until all disc has ceased. In cases of pneumococcic inf recovery is usually rapid, the lung expandin obliterating the empyema cavity. Whe infection is streptococcic, many weeks elapse before the infected cavity becomes erated. Some surgeons, to make drainage perfect and continuous, connect the drai tube to a pipe passing through the dressings and attached to a Bu air pump (Fig. 419). This ingenious measure is not often req During the after-treatment of cases of thoracotomy the patient should be p in the position found at the operation to be most favorable for drainage. position, especially if disagreeable, need not be kept up continuously but ad at intervals for a short time. It is wise to encourage the patient to sit u move about at as early a date as possible. Fresh air is of great value in treat

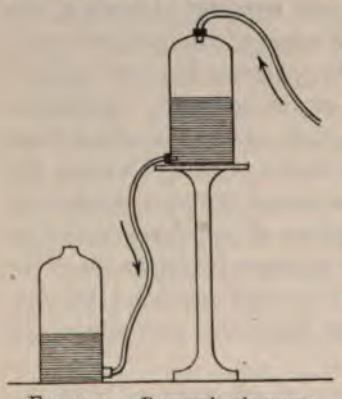


FIG. 419.—Bunsen's air pump.

Rutherford Morison thinks that an incision parallel to the ribs is to kink the tube (*a*) during respiratory movements, (*b*) from altered po after completion of operation. He operates as follows:

1. Verify presence of pus with hypodermic syringe.
2. Make a *vertical* incision down to rib and *across* intercostal space.
3. Push a sinus forceps (a closed, fine-pointed hemostat is satisfa into pleural cavity. Alongside the forceps introduce a director.
4. Open the forceps parallel to the ribs and pull them out while ope leave the director *in situ*. (This method avoids hemorrhage.)
5. Guided by the director, introduce drainage-tube.

inue tubular drain until there is no more pus than can be accounted
xternal wound. After removal of tube introduce director daily so as
ver if pus reforms necessitating reintroduction of tube.
acotomy by Puncture.—Make a small incision through the skin. Intro-
arge trocar into the empyema cavity. Through the trocar pass a large
catheter. Withdraw the trocar leaving the catheter in place. Con-
of the muscles around the catheter grip it until no air can enter along-

. Stevens (Southwestern Med., May, 1919) advises that a few ounces
e allowed to escape every two hours until in 24 hours almost all has
acuated. After this he advises the instillation of Dakin's solution every
rs; the old solution being allowed to escape before the fresh is put in.
when being used by the attendant the catheter drain is to be kept
y a clamp. The claim is made that by this method pus can be got rid
om 3 to 10 days and that the entire treatment is usually completed
eks.
. Dodge (Journ. A. M. A., June 21, 1919) after great experience during
emics of 1918 "relegates to the boneyard all of the many fancy treat-
f empyema evolved by the faddists who have been privileged to observe
of cases for a limited period of time." He has come back to the long
ed methods of free drainage which if adequately carried out render
of antiseptics such as Dakin's solution entirely superfluous.
chowitz (Surg., Gyn. and Obst., April, 1919) is a strong upholder of
omy without rib resection, generally in the eighth interspace just behind
erior axillary line. When the patient is put to bed "a simple instilla-
l suction apparatus (Fig. 420) is attached to the drainage tube by means
ube; at a convenient point a second attachment is made for a bottle to
the discharge escaping from the empyema cavity. Once an hour, or
less frequently as indicated, the syphon part of the apparatus is dis-
ed by clamping, and the instilling part of the apparatus, a Dakin con-
is opened, and the requisite amount of solution is allowed to run in.
e lapse of five minutes the suction apparatus is reopened, and the solu-
s secretions syphoned out. The suction is continued until the next
f instillation."
the above means the cavity is kept perfectly dry and the wound does
uire to have the dressings changed for a week or 10 days. After this
the apparatus and drainage tube are removed, the skin cleaned with
and the cavity is flushed with Dakin's solution through a soft rubber
(about 22°F.) until the return flow is clean. During the flushing the
is turned from the lateral to the prone position and vice versa. After
m 1 to 4 Carrel tubes are introduced to the various parts of the cavity;
drainage tube "with one fenestra guarded by a safety pin, so called
valve,' is finally introduced, to permit a free escape of the Dakin solu-
l secretions." The vicinity of the wound is protected by sterile vaseline
trips and the skin further away is covered by stiff zinc oxide ointment.
uze dressings are applied through which the Dakin tubes emerge above.
instillations of Dakin's solution are made in quantity equal to about

half the capacity of the cavity. Every 24 hours the dressings and tubes are changed. When sterility is attained (smears and cultures from cavity) and maintained for several days treatment is discontinued, the wound heals if left alone and permanent recovery ensues. If the cavity has not become truly sterile the wound will reopen.

In a few cases of healed empyema Moschowitz notes a very definite closed pneumothorax which disappeared after about a month by expansion of the lung.

The cases which, according to Moschowitz cannot be remedied by long continued Carrel-Dakin teratment are: (1) Cases complicated by large pleuro-pulmonary fistulas. (2) Cases with retained foreign bodies, (3) cases with side pockets or lateral branch sinuses (4) cases with necrotic ribs.

FIG. 420.—(*Report U. S. Empyema Commission.*)

Thoracotomy with resection of a segment of rib is usually much preferable to simple intercostal incision. In the latter the space is limited, finger exploration is difficult or impossible, and when the tube is introduced, it is very liable to be pinched between the ribs and rendered useless. Removal of a segment of one or more ribs does no permanent harm and the operation is exceedingly easy. Excision of a segment of rib is rarely required in children and as rarely should it be omitted in adults. In operating on non-localized empyema the incision may be made over the sixth or seventh rib in the mid-axillary line, or over the ninth rib just external to the angle of the scapula, which is the best position. In cases of localized empyema the opening must of course be made over the encapsulated pus. When incision is made in the mid-axillary line, the patient must be brought to the edge of the table over which the affected side may protrude a little. When the posterior site of operation is chosen, place the patient, with the

ound side uppermost, in a position midway between the lateral and ventral—*i.e.*, ying half over on his belly. *The sound side must never be undermost*, otherise respiration will be impeded. The surgeon under these circumstances stands n front of the patient and reaches the site of the operation by leaning over him.

These are the classical instructions always insisted on but rarely carried ut, except in trivial cases or by beginners who are much hampered by them. They are impracticable. In Friedrich's most extensive pneumolysis, the atient lies on the sound side. The researches of Schäfer (Transactions, ection on Surg. and Anat., American Med. Assoc., 1908) on artificial respiration nd the experiments and observations of Elsberg, clearly show that, *when possible*, the *prone* position is the position of choice for operations on the chest. C. E. Corlette (The Med. Journ. of Australia, March 1, 1919) strongly recommends the semiprone position for operations for empyema and pulmonary hydatids, with the side to be opened at the edge of the table and downwards. If the operator is seated this posture is very convenient for operations on the lower part of the thorax. In the case of hydatids, where drowning is a real

FIG. 421.—Rib shears.

peril, not only is this peril reduced to a minimum but the downward and outward rush of water brings the parasitic cyst well into the wound and greatly facilitates its extraction.

The Operation.—1. Make an incision two to three inches in length along the long axis of the chosen rib and divide the periosteum along a line midway between the upper and lower borders of the rib.

2. With a curved periosteal elevator separate the periosteum from the bone both externally and internally. The intercostal vessels are separated from the bone with the periosteum. In recent cases much care must be exercised when detaching the periosteum from the deep surface of the bone lest the pleura be prematurely opened; in cases of long duration there is so much pleural thickening that no accident is likely to happen.

3. Divide the exposed rib at the posterior end of the wound with bone forceps or rongeurs. For this purpose a costotome (Fig. 421) is convenient but not necessary. Grasp the portion of bone to be removed in the jaws of a sequestrum forceps, steady and bring it forwards, and divide it anteriorly with bone forceps. Two inches of bone should be removed.

4. Make a small incision through the deep layer of periosteum and the pleura. Let the pus flow out slowly. Interrupt its flow from time to time

by plugging the wound with gauze. Too rapid evacuation means pulmonary congestion, and this is liable to cause fatal anæmia of the brain. Proceed as in thoracotomy. If the cavity is large, it is easy to resect portions of two ribs subperiosteally through the same external incision. If this is done, the intercostal muscles and vessels should be ligated behind and in front of the pleural incisions and the two horizontal openings into the pleura united by a vertical cut to form an I-shaped wound (Fig. 422).

When the effects of an empyema are very menacing Lilienthal performs a simple thoracotomy under local anesthesia and introduces a drainage tube. When this simple operation has led to improvement he makes an incision, under local anæsthesia, usually along the seventh interspace from the angle of the rib to its costal cartilage. Before opening the pleura he administers nitrous oxide and oxygen and under that anesthetic opens the pleura freely—introduces a rib spreader which separates the seventh and eighth ribs for a width of several inches and gives a perfect view of the interior of the chest. Adhesions between the visceral and costal pleuræ must not be attacked but, with the finger, the lung ought to be separated from the diaphragm. In doing this it is not uncommon to open abscesses which would otherwise have been overlooked. Should the lung fail to expand, this failure is due to its being compressed and held down by organized exudates on its pleura. Lilienthal now follows Fowler and Delorme by incising the compressing membrane throughout the whole length of the lung and strips it off. The lung now expands. If decortication seems too risky he follows Ransohoff in making criss-cross incisions through the compressing membrane and so obtains expansion. In closing the wound he sutures the divided latissimus dorsi and serratus magnus but not the intercostal muscles.

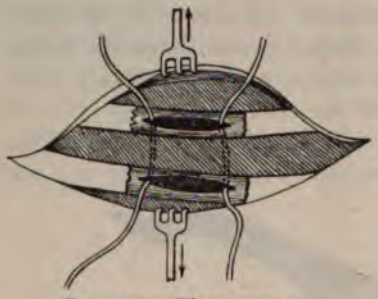


FIG. 422.—Thoracotomy.

This method of Lilienthal's appeals to the author as being conservatively radical.

Chevrier's Method. *Principles.*—The principles underlying drainage of the pleura in empyema are admitted by all to be the insertion of a proper tube through the chest wall at the lowest point. That this principle is not carried into practice is shown by the various devices used to obtain siphonage of the pus. A glance at Figs. 423, 424 and 425 will show why an opening in the posterior axillary line at the level of the sixth rib or even one in the scapular line, cannot give proper drainage whether the patient is recumbent or seated, whereas an opening at the costal angle (Fig. 425) must permit sufficient emptying of the vertebrocostal gutter in the recumbent posture.

The 'low point,' *i.e.*, the proper site for pleural drainage, is in the costovertebral gutter at the reflexion of the pleura from the chest wall on to the diaphragm. Normally the pleural reflexion is very low in the chest (about the eleventh intercostal space) but in disease the costo-diaphragmatic cul-de-sac

pushed upwards to a varying degree (Figs. 426 and 427) and in each case st be found by exploration during the operation.

Step 1.—Just external to the mass of the erector spinæ muscles explore for

423.—Segment of the 6th rib has been excised in posterior axillary line. Retention of fluid when patient is recumbent. (*Chevrier, La Pr. Med.*, Jan. 9, 1919.)

with an aspirating needle. This is best done under guidance of the fluoro- e as this permits the puncture being made "if not at the exact inferior limit he effusion at least in its lower zone.'

424.—Segment of the 6th rib has been excised in posterior axillary line. Retention of fluid when patient is erect. (*Chevrier, La Pr. Med.*, Jan. 9, 1919.)

Step 2.—Leaving the needle in place make an incision over the rib immedi- ly above the puncture, the patient being in the lateral decubitus lying on

the healthy side. The incision must begin at the outer border of the spinal mass of muscles and run outwards parallel to the rib. Incise the latissimus

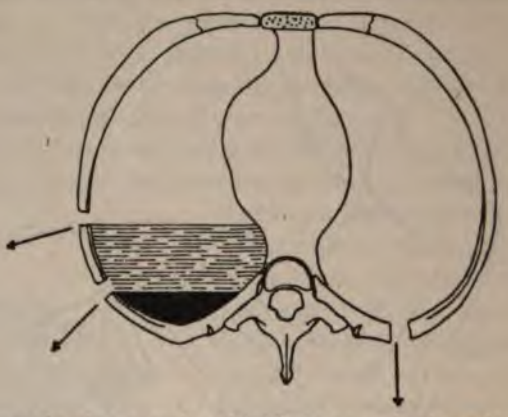


FIG. 425.—Diagram showing retention of fluid when opening is made in posterior axillary line or in scapular line. No retention when opening is at the bottom of the vertebro-costal gutter. (*Chevrier, La Pr. Med.*, Jan. 9, 1919.)

dorsi and sometimes the serratus posticus inferior, over the rib. Expose the external fibres of the ilio-costal muscle at the median end of the wound, and

FIG. 426.—Diagram showing the normal subpleural areolar tissue between the pleural reflexion and the diaphragm. (*Chevrier, La Pr. Med.*, Jan. 9, 1919.)

FIG. 427.—Diagram showing elevation of the pleural cul-de-sac due to (a) œdema and infiltration of the subpleural areolar tissue and (b) thickening of the pleura by false membranes. (*Chevrier, La Pr. Med.*, Jan. 9, 1919.)

beginning at this landmark divide the periosteum of the rib. Excise a segment of rib. Incise the pleura. With the finger plug the opening so as to regulate

the escape of pus and so prevent coughing and other reflexes due to too rapid evacuation. As pus ceases to flow turn the patient gradually on to his back until evacuation is complete when he is to be returned to the lateral decubitus.

Step 3.—Explore the pleura with the finger and find the low point. Guided by the finger inside the chest, open the thorax at this point and if necessary excise a segment of rib. Through this second opening introduce two *short* tubes of wide caliber. Dress but do *not* drain the first opening.

Step 4.—*Disinfection of the Pleura.*—Many surgeons having opened the chest in the classical site (6th rib; posterior axillary line) introduce Dakin's solution through small tubes. The opening being ill-suited for drainage permits retention of the solution which bathes the parts below the opening but not those at a higher level. Chevrier advises the use of gaseous disinfection which reaches every part of the cavity and obviates the use of the Carrel tubes.

Conduct compressed air or better oxygen from a cylinder to the bottom of a flask containing ether or ether with a little formalin. Let the air bubble through the ether and conduct it thus charged with volatile antiseptic, into the pleural cavity.

Berard and Dunet (La Pr. Med., April 3, 1919) consider that except in the tuberculous, slow recovery means defective drainage and emphasize the importance of considering the posture which will be assumed by the patient after operation before selecting the site for drainage. Most patients early assume the sitting posture and for such they find the low point in the pleura to be anterior or antero-lateral at the level of the 10th or 11th rib about 5 inches from the middle line.

Berard's Operation. *Step* 1.—Open the pleura in the ninth interspace in the posterior axillary line except in sacculated empyema where the incision is made over the pus as found by the exploring needle. Let the pus escape slowly. If the condition of the patient is precarious do not proceed further for a few days. If the condition of the patient permits proceed at once to

Step 2.—Through the opening pass a curved forceps through the empyema cavity to what would be the low point if the patient were sitting. This point varies, *e.g.*, pneumococcal infection as a rule produces much false membrane and adhesion with obliteration of parts of the pleural cavity while streptococcal infection does not. Guided by the forceps excise a segment of rib at the low point. Remove any masses of fibrinous material. Introduce one or two large drains.

Step 3.—Introduce one or more Carrel tubes through the original incision. Apply dressings. Connect the drains by tubing to a receiver. Keep the patient absolutely quiet for 24 hours. Dress the wound after the lapse of 24 hours. If the discharge is pure pus irrigation will be of value. Dakin's solution, nitrate of silver or salt solution may be employed through the Carrel tubes. About 150 or 200 c.c. may be used every 3 hours except at night. Each day remove, clean and replace both the Carrel and drainage tubes.

If an empyema persists for a very long time or if, after an apparent cure the drainage track reopens several factors may be to blame. (1) Defective drainage. (2) Imperfect sterilization. (3) Presence of foreign bodies in the pleura, *e.g.*, lost drainage tube, etc. (4) Osteomyelitis of ribs. (5) Secondary en-

capsulated abscesses of the pleura which have escaped drainage. (6) Subpleural pulmonary abscesses such as Moschowitz considers the cause of most, if not of all empyemata. (7) Small intrapulmonary abscesses draining into the pleura giving rise to pleuro-pulmonary fistulæ. (8) Broncho-cutaneous fistulæ where a portion of lung, the site of an open bronchus, has become adherent to the chest wall near the point of drainage and the tract between the bronchus and the skin has become covered by epithelium.

In all these conditions it may be necessary to perform some free exploratory operation such as Lilienthal's and during the operation correct the conditions present. Pleuro-pulmonary fistulæ often heal of themselves or after sterilization and perhaps direct suture. To obliterate a broncho-cutaneous fistula requires mobilization of the affected portion of the lung by Schede's thoracoplasty or some modification thereof, plus excision of the fistulous tract and closure of the open bronchus, but as Lilienthal writes "lung fistulæ from tuberculosis, bronchiectasis or multiple abscess of the lung should be let alone, for they constitute safety valves." . . . "Plastic closure of lung fistulæ is indicated when secretion is scanty? Encapsulated abscesses of the pleura at some distance from the original empyema region require direct and efficient drainage through an opening made by resecting a segment of rib. Reaccumulation of pus in empyema demands proper drainage and as already stated a formal exploratory operation may be necessary.

The cure of an empyema by drainage depends, first, on the free escape of the pus; and second, on expansion of the lung obliterating the pleural cavity with or without more or less complete adhesion of the parietal and visceral layers of the pleura. When the lung is unable to expand and approach the chest-wall, obliteration of the cavity may be obtained by bringing the chest wall to the lung. To accomplish this is the object of thoracoplasty.

Fluoroscopy has superseded all other means of observing the expansile power of the lungs.

Wilm's Operation for Empyema.—See p. 318.

Estlander's Operation.—Make a subperiosteal resection of three or four ribs (about 4 inches of each) through separate incisions, exactly as in thoracotomy with resection of rib. Instead of using separate skin-incisions the ribs may be exposed by a **U**-,**T**-, **H**-, or **I**-shaped incision, the soft parts being reflected as a flap or flaps, and then the ribs resected subperiosteally. This operation permits a falling-in of the chest-wall, but in many cases the parietal pleura is so thick and hard that it is inelastic, and the desired retraction of the chest cannot take place. To obtain proper retraction the following procedure has been adopted:

Schede's Operation (*Thoracoplasty*).—Beginning at the origin of the pectoralis major at the level of the axilla make an incision which goes downwards in a curve to the bottom of the pleural sac,—*i.e.*, the tenth rib in the posterior axillary line, crosses the chest-wall from the front to the back, and ascends to the level of the second rib at a point between the spine and the scapula. Reflect upwards the huge flap thus outlined, and include in it *all* the tissues superficial to the ribs and intercostal muscles. Resect subperiosteally all the ribs over the cavity, from their tubercles to their insertion into the costal cartilages. To do this it is best to divide the rib at its middle with bone for-

ceps, and, grasping the divided end of one of the fragments with sequestrum forceps, dissect it out of its periosteal bed. The other fragment is removed in the same fashion.

Bardenheuer has been compelled to excise even the first rib, the clavicle, and the scapula before he could obtain a satisfactory result.

Make a large incision through the thickened pleura to permit of thorough exploration. This exploration tells how many ribs must be excised and to what extent. Excise *all* the periosteum, intercostal muscles, and thickened pleura over the empyema cavity. There is not liable to be much hemorrhage from the intercostal vessels, owing to their being more or less obliterated by the disease, but the patients are usually debilitated, the operation is very severe, and hence it is necessary to clamp and ligate all the intercostal vessels. Hemostasis must be very carefully attended to. Some surgeons carefully scrape away all diseased granulation tissue, but all that is necessary is gentle wiping with gauze pads. Replace the flap of soft parts. This flap, at least if the disease has been extensive, will not by any means cover the defect, as its under or raw surface must be in contact with the outer surface of the retracted lung. Fasten the flap in position with sutures and properly applied gauze pads, so as to insure good contact between flap and lung. The remainder of the cavity must be filled with sterile (not iodoform) gauze and may subsequently be covered by Thiersch's skin-grafts or by flaps of skin. No poisonous antiseptics should be used during the operation, and the use of iodoform gauze is forbidden, owing to the great absorbing power of the tissues in question. Karewski finds vioform gauze as efficacious as iodoform, and perfectly safe as regards poisoning. Instead of replacing the reflected flap, Cheyne and Burchard recommend packing the whole cavity with gauze for a time, to permit of free drainage and of the formation of a layer of granulations on the deep surface of the flap.

As has been said, the operation is very severe, and the patients are always debilitated; hence is is often wise to refrain from completing the operation at one sitting, but to proceed step by step, *e.g.*, excising the ribs and indurated pleura from over the lower part of the empyema, and after this procedure has been recovered from, to advance higher.

The incision described is that of Schede, but an infinite variety of cuts have been advocated; as Kümmel says, almost ⅓ the letters of the alphabet have been imitated in forming incisions.

Delorme, Fowler, Beck, and others believe that the obstruction to obliteration of the empyema cavity is not so much the rigid chest-wall as the stiff, indurated, shrunken visceral pleura which imprisons and compresses the lung. These surgeons temporarily resect the thoracic wall, free the lung from its prison by "decortication," and close the chest. Jordan and Krause combine the method of decortication with Schede's operation. Most surgeons use decortication as an aid to incision of the thoracic wall, but discard the temporary resection.

Pulmonary Decortication.—George R. Fowler ("Med. News," June 15, 1901; "Am. Year-Book of Med. and Surg.," 1902) performed this operation in 1893 with very gratifying results. He writes: "An elliptical-shaped incision

was made to include the orifice of the sinus, the soft parts cleared, and about 3½ inches each of the fifth and sixth ribs removed . . . . Commencing at the site of the opening in the chest-wall, the pleura was isolated by blunt dissection in the direction of the diaphragm until the latter was reached. It was then peeled off the latter until its limit towards the median line was reached, where it was found to rest against the displaced pericardium, from which, after much difficulty, it was finally detached. This dissection was greatly impeded by the movements of the diaphragm as well as those of the heart. The dissection was completed by lifting the mass and finally detaching it from the lung above. Considerable expansion of the lung followed at once, and in the course of twenty-eight days this was so far complete that the normal vesicular murmur was present to the level of the seventh rib. . . . Save for a slight sinking-in of the chest-wall at the site of the resection of the ribs there is nothing to suggest the previous existence of an empyema."

Fowler formulates the following conclusions:

"1. Decortication of the lung is an operation adapted to all cases of old empyema in which extensive and preoperatively discoverable tuberculous lesions of the lungs are not present, and in which the patient's condition will permit of a major operation.

"2. It may be advantageously substituted for Estlander's operation. . . .

"3. It should replace Schede's operation in all cases.

"4. The method by extirpation of the diseased portion of the pleural membrane, including the visceral, cortical, and diaphragmatic portions, is the operation of choice.

"5. Failing this, visceral pleurectomy should be selected.

"6. Pleurotomy, with simple detachment of the visceral layer of the diseased pleural membrane, gives sufficiently good results to warrant the surgeon in resorting to this procedure in cases in which the condition of the patient will not permit of the application of the other and more desirable methods.

"7. Whatever operative method is adopted, as complete access to the cavity of the chest as possible should be obtained, and rapid closure of the opening in the chest-wall afterwards secured, since the complete re-expansion of the lung must depend largely upon the normal respiratory movements.

"8. Pulmonary or respiratory exercises should not be neglected in the after-treatment. . . ."

Delorme in 1894 performed an operation very similar to that of Fowler ("Amer. Year-Book of Med. and Surg.," 1902), and did it successfully under spinal cocainization. Out of twenty-nine cases of decortication by the Fowler method the functional results were eleven cured, six improved, nine unimproved, three died; as regards the cure of the empyema, seventeen were cured, nine unimproved, three died.

Delorme has devised a method of temporary resection of the chest-wall, by forming and reflecting a flap consisting of the *whole* chest-wall; this being done, he decorticates the lung, cleans the empyema cavity, and replaces the flap of chest-wall, providing of course for drainage. This operation has not found much favor.

Roux in operating finds that a long incision through the indurated visceral pleura answers the same purpose as decortication.

Ransohoff (Transactions Am. Surg. Assoc., 1914) makes use of discission, , a number of criss-cross incisions through the sclerosed visceral pleura and ls this thoroughly satisfactory.

Lilienthal's Major Noncollapsing Thoracoplasty (Annals of Surg., July, 9).* Place the patient on his sound side over a pillow to give a scoliotic ture. Hips flexed. Pillow between the flexed knees.

Step 1.—In the sixth or seventh interspace make an incision from the costal le to the cartilage. Parts of the latissimus dorsi and serratus magnus are ded. If possible avoid the old drainage wound. Divide the intercostal ctures in the middle of the wound for about two inches close to the upper

FIG. 428.—(*Lilienthal*).

order of the lower rib. Enlarge the intercostal incision in both directions ntil large enough to permit separation of the ribs by blunt traction and exposing nough of the interior to work safely and keep clear of the lung. Enlarge the ound to the full size of the skin incision. Separate the ribs slowly with a rib tractor. Usually a separation of three inches is possible. In old empyema ses the chest wall is so fixed by fibrous tissue that it is necessary to divide om one to three ribs upwards (occasionally downwards) at the posterior end the wound. The blades of the retractor can now be separated 6 inches or ore (Fig. 428). (When ribs have been divided it is wise to cut away about ½ ¾ inches of the anterior portion of each to prevent postoperative pain and uma by the grinding together of the cut ends.)

*Anesthesia —intrapharyngeal (p. 288).

Step 2.—Every part of the empyema cavity lies exposed. Incise the visceral pleura from apex to base but do not wound the lung. This incision widens as the lung expands. Peel off the visceral pleura or if this is too difficult make numerous criss-cross incisions through the visceral pleura (Ransohoff's discision) which permits thorough expansion. Inspect the whole cavity, hunting for secondary pockets. Treat with great respect adhesions of the lower lobe to the diaphragm as the attenuated flat pulmonary flap is often mistaken for the diaphragm or *vice versa*. As a rule it is unnecessary to peel any part of the lung from the chest wall and dangerous because of hemorrhage and opening avenues for infection.

Step 3.—When it is evident that no more expansion can be secured, clean the original drainage tract and pull a tube through it from within out. Suture the large wound in three layers using chromicized catgut for the buried sutures. Do not use pericostal sutures, even although, as is not uncommon, it is impossible to bring the muscles close together. Drainage from the imperfectly closed muscle wound takes place into the thorax and thence out by the tube.

After Treatment.—Begin blowing exercises early, even within 24 hours. After 3 days treat the cavity by the Carrel-Dakin method injecting not more than one-half ounce of fluid every two hours. The usual time of healing is about four weeks from the day of operation. In a personal communication Lilienthal reported 41 cases with one death. In two or three cases not enough time had elapsed to justify an opinion as to permanent result, in all the others a cure was obtained.

Roux-Berger finds that secondary retraction and immobilization of the lung are liable to occur after decortication. Therefore after freeing the lung thoroughly by an operation entirely similar to Lilienthal's he fixes the lung to the chest wall (pneumopexy) by strong and ample sutures. When this is done drainage is permissible if desirable.

The after-treatment of cases in which any of the ordinary methods of thoracoplasty has been used is prolonged; often a year or more elapses before a cure is obtained, and during this time several subsidiary and plastic operations may be necessary. One would naturally expect that ultimately great deformity, especially scoliosis, would be present, and that the lung deprived of its thoracic wall would be useless. This is, however, not the case. Wonderfully little deformity persists; the lung expands and becomes a useful organ. In many cases there is very evident reformation of ribs. As Karewski says, we must *not* be too sparing in removing large portions of ribs, especially in children, when this is demanded, as the lungs can still expand, and thus thoracic deformity may be avoided or reduced to a minimum.

Resection of the thoracic wall does not *per se* cause much deformity. The deformity depends on the amount of intrathoracic changes. It is not the removal of the chest-wall but the shrinking of its contents which is to blame (Th. Glück, Archiv für klin. Chir.," lxxxiii, 587).

When empyema affects both pleural cavities the following operations may be performed: (1) Double aspiration; (2) incision on one side, aspiration on the other; (3) incision on both sides; (4) resection and aspiration; (5) resection and incision; (6) resection on both sides (resection may include decortication).

ellin ("Berliner klin. Woch.," 1905, No. 45) recommends the operation of cision with drainage in double empyema; operation to be limited to one side a time, and aspiration to be done one or two days prior to the incision. ocal anæsthesia is usually sufficient.

OPERATIVE TREATMENT OF PHTHISIS PULMONALIS

Excision of portions of the lung for tuberculosis has been of little or no value. he same is true regarding the treatment of phthisical cavities by means of aspiation and of injections. When nature cures tuberculosis she does so by conerting the granulation tissue into mature scar tissue. If a phthisical cavity ecomes obliterated, it is by the contraction of scar tissue, and this contraction auses a deformity or sinking in of the chest-wall.

Establishment of Artificial Pneumothorax.—In pulmonary tuberculosis if the visceral and parietal pleuræ are not too much adherent the lung may be collapsed and put at rest, temporarily, by filling the pleural cavity with some non-irritating gas which is not too readily absorbed. Carson in 1840 suggested the treatment but his work was forgotten until Forlanini and Murphy independently adopted the same idea and recommended the use of nitrogen. Brauer enthusiastically advocated the method. Nitrogen displacement is of special value in early progressive lesions, in cases where there is persistent fever, where there is profuse or repeated hemorrhage and where there is cavity formation in one lung.

The dangers incident to the operation are (*a*) shock. This is most noticeable in early cases and may be lessened by the careful use of local anæsthesia; (*b*) embolism from puncture of a vein; (*c*) when the disease is very extensive, a comparatively small injection of gas may cause suffocation as the functional capacity of the lung is very small.

In cases where the pleura is widely and strongly adherent the pleural cavity is so obliterated that the operation is impossible; in other cases, where there are localized adhesions, introduction of gas may be of great value but it is difficult to place the point of the needle in the pleural cavity and to be sure that it is there. Brauer, under local anæsthesia, makes an incision down to the pleura and inspects it. A transparent pleura with the lung surface moving to and fro beneath it exposes a field in which it is easy to complete the injection without danger to the lung. Most operators discard the exploratory incision and content themselves with thoracentesis. It is wise to keep the patient quietly in bed for at least twenty-four hours and to give a hypodermic injection of morphine gr. $\frac{1}{4}$ with atropine gr. $\frac{1}{150}$, about half an hour before the operation.

The best site for puncturing the chest is somewhere in the anterior or mid-axillary line in the fifth, sixth, or seventh intercostal space. The patient is usually placed in a semi-recumbent position and turned slightly on to the sound side. Novocaine is used as the local anesthetic and special attention must be given to anesthetizing the pleura. The proper use of a local anesthetic is of very great importance in preventing pleural reflex and shock. In very nervous patients suffering from early unilateral disease Woodcock and Clark (Brit. Med. J., Dec. 12, 1914) advise that, at the first sitting , after going through all the ritual of preparation nothing be done beyond injecting the local anesthetic. After four days the process is carried further and the nitrogen

needle is pushed in until oscillation of the manometre shows that it is in the pleural cavity. At the third sitting a small amount of gas is introduced.

After the anesthetic has been injected, puncture the skin with a tenotome and introduce the nitrogen needle. Floyd's needle is good (Fig. 429). The puncture must be made slowly and deliberately until digital sense indicates that the correct depth has been reached when the trocar is to be withdrawn, the middle cock closed and the lateral opening connected with the manometre of Samuel Robinson's apparatus (Fig. 430). Before making this connection, isolate the manometre from the nitrogen circuit. If the needle is in the pleural cavity the negative intrathoracic pressure is indicated by the manometre and as this pressure varies with the respiratory movements so also does the manometre oscillate. "If the needle point is partly obstructed by contact with the adhesions or lung tissue, this oscillation may not be more than 0.5 cm. Such trifling oscillation is also found when the pleural space entered is one of small capacity on

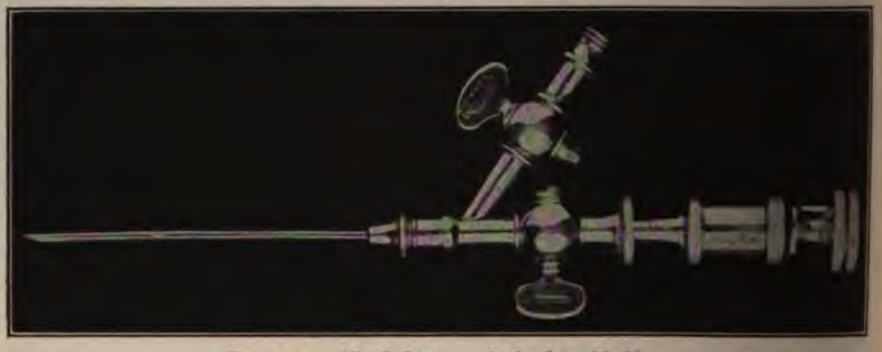


FIG. 429.—(*S. Robinson, Arch. Int. Med.*)

account of neighboring adhesions; but whether this oscillation be a complete or restricted one, its presence is an unerring guide that nitrogen may then be safely introduced. If the oscillation has been small, the amount of nitrogen injected is correspondingly low. A free oscillation of from 3 to 4 cm. is evidence of greater lung mobility, and the extent of the pneumothorax produced is correspondingly greater" (Robinson, Arch. Int. Med., IX, 467). The needle may require considerable manipulation or its site of insertion may require to be changed before the pleural cavity is safely penetrated. As soon as it is certain that the needle is in the pleura, close its connections with the manometre and open those with the nitrogen bottle and permit the nitrogen to flow slowly into the chest. The amount of nitrogen introduced varies with the case and with the ideas of the surgeon. Forlanini begins with a very small injection, Robinson with a larger. "If the nitrogen flow under moderate pressure is apparently unrestricted, 600 to 800 or even 1000 c.c. may be injected at the first operation" (Robinson). The feelings of the patient and any symptoms of distress, etc., which he may manifest must guide us frequently as to the amount of injection. Several injections at intervals of a week or of several weeks may be necessary before a complete pneumothorax is established.

Morriston Davies writes (Brit. Med. J., April 25, 1914): "My experience is that the nitrogen is absorbed from the pleural cavity much more quickly during

er than during the later months of treatment, and it is essential therefore first few refills should be done at more frequent intervals than the sub- ones. During the first six months of the treatment I run a fresh supply en every six weeks, but after that I allow an interval of eight weeks to There is no necessity for the patient to be confined to bed at these times, ke him lie down for three or four hours after the injection. Those who rk are allowed to return to it the next day, and suffer little or no incon- from the increase in pressure. The amount of nitrogen required to

FIG. 430.—(*S. Robinson, Arch. Int. Med.*)

hat which has been absorbed varies from 500 to 1000 c.c. At the end of allow the lung to re-expand so as to be able to make fresh clinical graphical observations, but as a rule it is advisable to maintain the dis- t for at least eighteen months. If, during the earlier period of time, the llowed to expand and the two pleural membranes to come into contact h other, there is considerable risk that they will become adherent."

e 430, showing Robinson's apparatus, illustrates the principles em- n all forms of apparatus. Two bottles of 3500 c.c. capacity are em- One is stationary and filled with water containing 2 drams of pyrogallic take up any oxygen which may enter in conjunction with nitrogen. gas is then forced into the stationary bottle (*A*) displacing the water bottle (*B*). At completion of this displacement the apparatus is ready

for use. On opening certain cocks the water in bottle *B* replaces the nitrogen in bottle *A*, gradually filling it. The difference in the water levels of the two bottles represents the pressure under which the nitrogen is injected, the rapidity of its injection being regulated by the size of the opening in any one of the cocks. When bottle *B* is full, the maximum pressure is obtained, amounting to about 14 c.c. of water. As the water levels approach one another bottle *B* may be raised as in Fig. 430, thus maintaining the pressure until most of the nitrogen has been displaced, when the pressure is necessarily reduced. With this hydrostatic mechanism the pressure may be varied at will, never attaining the dangerous limit. The arrangement of cocks *d*, *e*, and *f* corresponds to the substitution of a three-way cock at point *g*. In other words, with cock *d* closed and *e* and *f* open, a direct connection is established between the thoracic cavity and the manometre. With cock *f* closed and *c*, *d*, and *e* open, connection is made between the confined nitrogen and the manometre, thus recording the pressure represented by the difference in water levels of bottles *A* and *B*. With cock *e* closed and all others open the nitrogen passes directly from bottle *A* into the pleural cavity.

Numerous attempts have been made to permit atmospheric pressure to obliterate phthisical cavities by the resection of the bony chest-wall directly over the cavities. These attempts have failed because of insufficient sinking in of the chest-wall.

Friedrich (in conjunction with his colleague Brauer), recognizing the danger of pneumothorax, and that adhesions between the lung and the chest-wall can easily prevent sufficient collapse of the lung when gases are put into the pleura, came to the conclusion that a very free removal of the rigid chest-wall without opening the pleura would be of value. This procedure he has carried out and has named pneumolysis. The cases in which pneumolysis is justifiable must present the following conditions: (*a*) The disease must be mostly confined to one lung; the opposite lung can rarely be intact. (*b*) The disease *must be progressing* in spite of proper and thorough medical and climatic treatment. (Friedrich's cases were sent from sanatoriums where they had been under observation for several months or years.) (*c*) The general condition must be fair in order to withstand the severe operation.

In most of the cases operated on by Friedrich from 120 to 200 c.c. of sputum containing bacilli was expectorated in 24 hours, and fever was present up to the time of operation.

Preparatory Treatment.—For three days administer digitalis hypodermatically. Attend to the bowels without weakening the patient. Give nutritious, easily digested food. In adults (not in the young) administer morphine an hour before operation.

The Operation.—Anæsthesia.—In adults inject as much as 500 c.c. or more of Schleich's No. 2 solution but minus morphine and plus 8 drops of adrenalin to the 100 c.c. The injection is made along the line of incision and under the flap to be elevated. Most of the solution escapes during the operation. Sometimes Friedrich lightly freezes the skin along the line of incision with a spray of ethyl chloride. After the skin and muscle flap is reflected chloroform is administered.

In the young (under sixteen years) chloroform is used from the beginning in n Braun's apparatus. In a case seen by the author only seven grams of loroform sufficed.

FIG. 431.—(*Friedrich.*)

FIG. 432.—(*Friedrich.*)

Lay the patient on his sound side. Let an assistant hold the arm (well protected) and be ready to elevate it over the patient's head.

Step 1.—Make the huge **U**-shaped incision shown in Figs. 431 and 432. In the female the breast is avoided. (Fig. 433.)

Step 2.—Reflect the flap outlined. The flap contains skin, all the musc down to the ribs, and the scapula. Obtain free access to every rib from t tenth up to and including the second.

Step 3.—If local anæsthesia has been used, administer chloroform now.

Step 4.—Beginning at the tenth rib proceed as follows: (*a*) Reflect t periosteum upwards and downwards from the whole external surface of t rib. (*b*) Near the middle of the rib separate the periosteum from the lower ed of the bone (for this purpose a nick with a knife is usually necessary befo

FIG. 433.—(*Friedrich.*)

the elevator can pass under the rib). With gauze, finger and elevator careful separate the periosteum plus the intercostal vessels from the groove under t rib. Complete the separation of the periosteum from the deep surface of t rib, and pass Friedrich's curved elevator completely around the rib. T curved elevator being round the rib, pull it (the elevator) with force back to beyond the angle of the rib and forwards to the junction of the rib and co cartilage. Divide the rib at its junction with the cartilage by means o costotome. Seize the end of the rib and pull it outwards. Pass a finger al the visceral side of the rib to its head, to protect the pleura. Twist the until it comes away. (Sometimes the head of the rib is torn from its con tions; sometimes the neck of the bone is fractured.)

p 5.—Repeat Step 4 on each rib until the second is removed.
p 6.—With gauze and sharp dissection remove the intercostal muscles
he pleura. The twisting away of the ribs obliterates the intercostal
s.
uration of operation up to end of Step 6 was twenty-five minutes in
e seen by the author.)
p 7.—Apply ligatures. Replace the flap and unite the divided muscles
atgut. Place a drain along the deep wound corresponding to the heads

FIG. 434.—(*Friedrich.*)

ribs. Close the skin wound. Apply abundant dressings. Opera-
n the right side is much more dangerous than on the left because of
dislocation.
er-treatment.—Administer hypodermatically 1 c.c. camphor oil forty per
40 per cent.) every hour by day and every two hours by night. Give
s freely. Each night inject 1½ L. salt solution in the inguinal region.
lt solution has a most favorable influence on respiration. Administer
frequently.
eight cases only two died and these had advanced secondary lesions
ere.
course, after recovery, medical and climatic treatment must be continued.

Figs. 433 and 434 show the extent of compensatory emphysema established in the sound lung and the great displacement of the heart.

In a few weeks the sputum has diminished from 150 or 200 c.c. to 20 or even 5 c.c. and the patients have lost their fever and gained weight. The operation is *sub judice* but seems to be of considerable promise.

Wilms' Operation.—(Wilms. "Muench. med. Woch.," 1911, No. 15; Kolb, "Muench. med. Woch.," 1911, No. 47.) In cases of unilateral chronic tuberculosis of the upper lobes of the lung and in total empyema Wilms endeavors to diminish the thoracic cavity by resecting 3–4 cm. of several ribs near their angles, supplemented when necessary by resection of the costal cartilages. The weight of the arm, among other factors, causes very great lessening of the upper thoracic cavity after operation; the lower thorax is not so well obliterated, hence in empyema it may be necessary to excise completely some of the lower ribs in a secondary operation.

Wilms' operation like Friedrich's aims at pneumolysis and obliteration of the pleural cavity, while Freund's operation of chondrotomy aims at restoration or improvement of thoracic motion and at an increased thoracic cavity.

Use a local anesthetic (Wilms).

Step 1.—Make an incision parallel to the spine, over the angles of the ribs, from the first rib downwards as far as may be necessary. Reflect the skin so as to expose about 4 cm. of the subjacent muscles.

Step 2.—Split the fibres of the trapezius and rhomboideus muscles over the second rib. Retract the muscle vigorously so as to expose about 4 cm. of the first, second, and third ribs. Excise subperiosteally about 3–4 cm. of these ribs. In similar fashion split the muscles over the fifth rib and through that opening excise 3–4 cm. of the fourth, fifth and sixth ribs. Split the muscles over the seventh rib and excise through this opening portions from any of the lower ribs which prevent falling in of the chest-wall.

Step 3.—Make an incision parallel to and 1–2 cm. from the edge of the sternum and excise the whole of the costal cartilages of the ribs which have been divided posteriorly.

Step 4.—Apply dressings held in place by adhesive straps firmly applied. Have the patient lie on the affected side.

Sauerbruch's operation is very similar to that of Wilms'. The incision is made about 3 finger-breadths external to the vertebral spines, its lower end being extended outwards above the tenth rib. Through this incision the scapula is reflected outwards and portions of ribs are resected from the ninth and tenth upwards to and including the first. Of the lower ribs, 6 to 10 cm. of the upper 3 to 6 cm. should be removed. It is necessary to resect the ribs in the back close to the transverse processes of the corresponding vertebræ and it is important to resect small portions of the tenth or even of the eleventh rib since only in this way can the diaphragm be relaxed and also mobilized and the lung deprived of its inspiratory power (Henschen, Trans. Am. Surg. Assoc., 1914). Sauerbruch (Technik der Thoraxchirurgie) has also modified the Friedrich operation by operating in two stages. He first resects the ribs from the fourth or fifth to the eighth exactly as in Friedrich's method. After a few weeks he resects the remaining upper ribs as follows: Place the patient on his back with

e shoulders slightly elevated. Abduct and elevate the arm as much as possible. ake a skin incision from without inwards along the clavicle. Continue its ner end downwards corresponding to the course of the internal mammary tery. Reflect the flap of skin and pectoralis outwards so as to expose the ner two-thirds of the upper ribs. Subperiosteally resect the *second* rib as ttensively as possible—without injuring the pleura. This permits the apex f the lung to sink inwards away from the first rib. After raising the periosteum arefully and slowly, gnaw through the first rib with a narrow-bladed rongeur orceps, at the same time pushing the subclavian vein with the finger out of harm's way. After dividing of the rib remove as much as possible of its median and lateral segments. Resect the third and fourth ribs. Replace the reflected flap and suture it.

Tuffier, Extrapleural Implantation of Fat.—*Lipotamponade.*—In cases of apical tuberculosis Tuffier operates as follows: Make a free incision through a suitable intercostal space down to but not through the parietal pleura. By blunt dissection separate the unopened pleura, corresponding to the apex, from the endothoracic fascia. Push the apex of the lung, covered by the pleura, downwards, thus creating a large extrapleural cavity. Fill this cavity with a free, *i.e.*, non-pedunculated mass of fat. Close the wound. Tuffier has found the operation useful and Wilms has had similar results. Instead of fat, Baer has used paraffin for the tamponade. Wilms thinks that in chronic phthisis with contraction the apical compression is insufficient; therefore he combines it with his own operation of rib resection in the lower thorax.

Ligation of Branches of the Pulmonary Artery.—When one of the principal branches of the pulmonary artery is tied there results induration and later contraction of the territory supplied, but without pneumonia. Sauerbruch has taken advantage of this in the treatment of bronchiectasis. To get the full benefit of this therapy it is necessary to complement it by subsequently mobilizing part of the chest-wall by means of a more or less limited resection of ribs. The arterial branches going to the left lower and right upper lobes of the lungs are specially suitable for ligation (Schumacher). To ligate the artery of the left lower lobe, place the patient on his right side with a pillow so placed as to make the left chest very prominent. Pull the left arm upwards and backwards. Make a long incision in the fifth intercostal space. Use differential pressure apparatus or intratracheal insufflation. Be specially careful in opening the pleura because of the probable presence of adhesions. Separate the upper and lower lobes of the lung in the interlobar fissure and expose the pedicle of the lower lobe in which there lie the pulmonary artery and vein and the bronchus. The bronchus lies between the two vessels and the artery is the most superficial. Do not depend on pulsation in orientation as it is fallacious. Once the artery is found pass a ligature round it from the bronchus side. For one or two days after operation the breathing is shallow because of the pain.

Willy Meyer has experimentally ligated the pulmonary artery within the pericardium so as to avoid the difficulties of Sauerbruch's method when adhesions are present (Trans. Am. Surg. Assoc., 1913). Such operations are sometimes supplemented with unilateral section of the phrenic nerve in the neck

whereby half the diaphragm is paralyzed and pushed up into the chest by the intra-abdominal pressure.

Exposure of the Phrenic Nerve in the Neck.—Make an incision along the posterior edge of the lower two-thirds of the sternomastoid muscle. Doubly ligate and divide the external jugular vein. Retract the sternomastoid forwards. Recognize the scalenus anticus muscle as it runs downwards to be inserted into the scalene tubercle on the first rib. Low down in front of this muscle is the subclavian vein; behind the muscle is the subclavian artery. The phrenic nerve runs from above downwards and inwards obliquely on the anterior or superficial surface of the scalenus anticus and is somewhat overlapped by the internal jugular vein.

FREUND'S OPERATION FOR ALVEOLAR PULMONARY EMPHYSEMA AND APICAL PHTHISIS

In 1859 Freund demonstrated two important conditions of the thorax which were primary (direct or indirect) causes of pulmonary disease.

1. Impeded development of the first costal cartilage caused stenosis of the upper aperture of the thorax and this symmetrical or asymmetrical stenosis influenced the structure and function of the apex of the lung so as to render it susceptible to tuberculosis. If pseudarthrosis developed in this stenosed and immobile costal ring and permitted motion, then a natural cure of the apical tuberculosis supervened. For fifty years Freund urged operation to produce such pseudarthrosis and for fifty years his colleagues shook their heads to his pleadings.

2. Degeneration of the costal cartilages causing their enlargement and immobility in a position of inspiration (previously observed by Dupuytren) caused a widening of the lower thoracic opening and a flattening and atrophy of the diaphragm.

The resulting permanent dilatation of the thorax led to permanent distention of the lung, *i.e.*, to alveolar emphysema.

Freund formulated the following indications for operation: When stenosis of the upper aperture is demonstrated and there is repeated catarrhal trouble in the apex of the lung, operation is proper as a prophylactic measure; when under similar conditions an apical tuberculosis is present but does not extend below the second rib, then a curative operation is indicated.

An operation is indicated in the early stages or in fully developed alveolar emphysema before the occurrence of secondary affections with atrophy and great rarefication of the lung tissue and atrophy of the diaphragm, when rigid dilatation of the chest-wall is demonstrable. ("Archiv für klin. Chir.," xcii, 974.)

Von Hansemann ("Archiv für klin. Chir.," xcii, 993) considers Freund's operation very advisable in typical cases of apical phthisis where there is stenosis of the upper opening of the thorax and where the disease *does not extend lower* than the second or third rib.

Mohr emphasizes the fact that Freund's operation, in alveolar emphysema, is directed not against the pulmonary dilatation but against the dilated and rigid thorax which causes the emphysema. Operation must be followed by

proper gymnastic exercises so that the muscles used in respiration receive proper education and training. Before deciding on operation it is important to study the condition of the heart, etc., lest relief of the thoracic rigidity might affect disastrously cardiac compensation. Mohr's experience with Freund's operation is considerable and he has been much impressed with its value.

Freund's suggestion has been carried out successfully by O. Hildebrand, Bramann and Haasler, Passler and Seidel, Goodman and Wachsmann, Friedrich, etc.

The value of Freund's operation was substantiated by the reports of many operators at the German Surgical Congress of 1910.

The operation may be done under local or general anæsthesia. Cardiac insufficiency, asthma, chronic bronchitis and albuminuria according to Friedrich are not necessarily contraindications to operation.

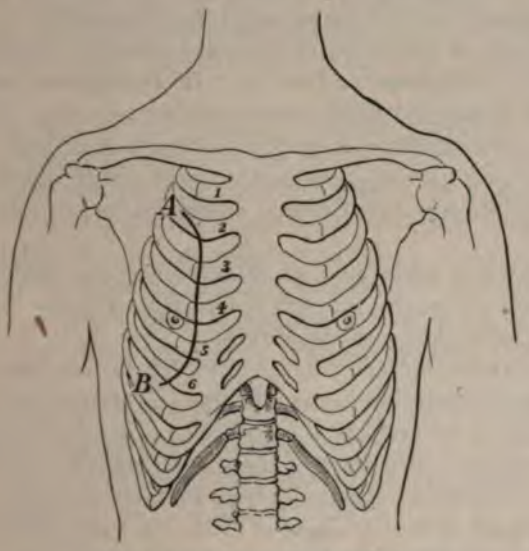


FIG. 435.—Freund's operation.

The Operation.

Step 1.—Make the somewhat curved incision A B (Fig. 435). Expose the ribs and costal cartilages for 1½ to 2½ inches at their junction.

Step 2.—Excise about 1½ to 2½ inches of the ribs and cartilages at their junction. This is done to the 2d, 3d, 4th, 5th, and 6th ribs.

When the operation is done for apical phthisis the first rib ought also to be removed.

Carefully remove the periosteum and perichondrium corresponding to the excised portion of rib. This is done to prevent reformation of rib. Andrews obliterates the groove left by each cartilage with a circular stitch of catgut in order to prevent reformation of cartilage from fragments of perichondrium which may have escaped removal. He removes only segments of four ribs.

Axhausen ("Zentralblatt für Chir.," May 14, 1910) notes the difficulty of excising the periosteum and perichondrium left after removal of the ribs, and

suggests overcoming this difficulty by applying the thermocautery to the membrane instead of endeavoring to excise it.

On purely theoretical grounds it seems to the author that it would be wise to reflect a flap of periosteum, base outwards, from the anterior surface of the ribs, corresponding to the segment to be removed, and after removal of the segment of rib to carefully cover the cut end of the rib with the periosteal flap.

In one of Friedrich's cases (local anæsthesia) the patient drew attention to the immediate relief obtained in his diaphragmatic respiration as soon as a rib was divided.

E. Douay (These de Doctorat. Paris, Ref. Journ. de Chir., XV, 303, Sept., 1919) denies Freund's theories regarding the causes of emphysema. In his opinion the patients are suffering from a thoraco-visceral dyspneic syndrome with associated alterations in the thorax, lungs and heart. If rigid dilatation of the thorax is an element in the respiratory embarrassment of the emphysematous, a much more important factor is dilatation of the right heart of which the first sign is dilatation of the right auricle. Douay (supported by Delbet) considers operation proper (1). In emphysema with considerable dilatation of the thorax and diaphragmatic embarrassment. (2) In emphysema with partial thoracic rigidity due to sterno-chondral ankylosis. (3) In emphysema with circulatory disturbances and cyanosis due to dilatation of the heart especially auricular, whether thoracic dilatation or rigidity be present or absent.

When operation is performed for dilatation of the right auricle it should consist of excision of the 3rd, 4th, 5th and occasionally the 2nd, and 6th costal cartilages along with their peri-chondrium.

Henschen ("Archiv für klin. Chir.," xcvi, Hft. 4) considers Freund's chondrotomy the logical operation in cases of thoracic stenosis where the stenosis is due to ossification of the first costal cartilage and explains the location of apical tuberculosis in adults. This form of stenosis Henschen calls "Hart's anomaly of the aperture." It differs essentially from Freund's anomaly where a primary want of development of the cartilage, or of the rib itself, substitutes an antero-posterior oval for the normal transverse oval of the thoracic aperture, and where a flattening of the paravertebral portions of the rib causes subapical compression of the lung with all its ill effects. For this condition Henschen advises *paravertebral decompressive excision* of the first rib.

Henschen's Operation.—Place the patient in the semiprone position with the healthy side undermost. Put a pillow under the upper chest in such a manner that the arm (of the affected side) can be laid over it and strongly pulled outwards and downwards, the pillow acting as a fulcrum to the arm.

2. From the dorsal spine of the sixth and seventh cervical vertebræ make an incision through the skin outwards to the acromial end of the clavicle. At a point on this line 3 to 4 finger-breadths external to the spines of the vertebræ make an incision parallel to the vertebra and about 3 inches long. Part of this vertical cut is above and part below the horizontal incision. Reflect the skin flaps thus outlined.

3. Split the exposed portion of the trapezius in the line of the horizontal wound; divide the rhomboid and the superior serratus posticus; divide fully

alf of the levator anguli scapuli. With a retractor pull the upper angle of the capula strongly downwards.

4. With the finger identify the tubercle of the first rib and bluntly isolate segment of the rib for a distance of about 2–3 cm. outwards from the tubercle. ubperiosteally resect this segment of rib. If the second rib aids in producing he stenosis excise part of it also through the same wound. Apply a thermo-autery to the periosteum to prevent reformation of bone.

5. Attend to hemostasis. Close the wound. Dress.

Torek's Interpleural Pneumolysis (Surg., Gyn., Obst., July, 1914, p. 1).—When injections of nitrogen are unavailable because of the presence of adhesions, Torek endeavors to produce collapse of the lung without the dangers of the Friedrich operation. He operates as follows: Anæsthesia by intratracheal insufflation. Trendelenburg's posture to prevent discharges, possibly expressed rom the diseased lung, gravitating into the healthy lung.

Step 1.—Make a 6-inch incision through the 6th or 7th intercostal space at the postero-lateral aspect of the chest. Attend to hemostasis before the pleura is incised.

Step 2.—Incise the parietal pleura. Separate the ribs with retractors. Gently with the finger, and later with the whole hand, separate the adhesions between the visceral and parietal pleuræ. Some firm strands may require cutting. When the separation is completed the lung will collapse as much as the degree of its infiltration or consolidation permits.

If any superficial pulmonary cavities have been opened during the operation demonstrate their openings, if necessary, by having the anesthetist inflate the lung. Close any such openings by inversion sutures after the lung has collapsed again.

Step 3.—Close the pleural cavity without drainage. Close the chest by pericostal sutures. Close the skin wound.

As the air in the pleural cavity may become absorbed it may be necessary subsequently to fill the cavity with nitrogen gas.

OPERATIVE TREATMENT OF COSTAL TUBERCULOUS OSTEITIS AND OF THE RESULTING ABSCESSES

The most common and least efficacious treatment of the above affection is incision, thorough scraping with a sharp spoon, and iodoformization. This treatment is often insufficient, and when we remember that the excision of a segment of a rib is easy and harmless, then we can have little hesitation in adopting more radical and effectual methods.

Let it be assumed that we have to treat an unopened abscess, not adherent to the skin, originating from a tuberculous focus in a rib. Cheyne recommends an operation on the following lines: Make a vertical or oblique incision through the skin over the abscess. The incision ought to extend at either end beyond the abscess itself. Retract the edges of the wound and dissect back the skin from over the abscess until the whole swelling is freely exposed. Instead of the above, a curved incision may be used and a more r less U-shaped flap of skin elevated to expose the swelling. If possible, without rupturing the abscess, dissect it free from its surroundings except where

it is attached to the offending rib. Expose the offending rib or ribs at each side of the abscess and subperiosteally divide them in such a manner that the whole mass, abscess cavity and rib, is removed *en masse*, leaving the posterior layer of periosteum *in situ*. On the normal cadaver this operation is difficult to do without puncturing the pleura, but in cases in which it is indicated, although caution must be exercised to avoid this accident, the accident is unlikely to happen, as the disease has caused thickening of the tissues. After removal of the abscess and segment of rib, examine carefully the remaining periosteum; if it is diseased, curette and swab it with liquid carbolic acid (neutralizing the acid by wiping with alcohol) or cautiously excise the diseased tissue. Attend to hemostasis and close the wound, after having provided for drainage. If it is impossible to excise the abscess intact, evacuate it either by incision and careful cleansing or by aspiration or puncture. If aspiration or puncture has been employed, close the puncture in the abscess wall with a clamp or a purse-string suture before continuing the dissection. The same principles of treatment must be applied in cases of osseous disease with sinus formation.

When an infective disease, such as tuberculosis or typhoid, attacks one or more of the costal cartilages, repeated operations may be necessary before recovery takes place. Roux considered such cases almost incurable until he attacked them as follows: Through healthy tissue make an incision all around the focus of disease. Divide the skin, muscles, cartilage, and, if necessary, the bone. *When this cut has become sclerosed*, proceed to excise the disease. The wall of sclerotic tissue provided by the primary operation prevents spread of the disease in the now resistant cartilage ("Rev. de Chir.," No., 1904).

Axhausen ("Archiv für klin. Chir.," xcix, 219) after removing the disease covers the healthy stump of cartilage either with a pedunculated flap of muscle or by inverting the skin wound over the cartilage and suturing the skin to the tissues under the cartilage. The whole principle of treatment is to leave *no dead space* opposite the divided costal cartilage. Experience shows that covering the end of the cartilage with flaps of perichondrium does not fulfil the requirements. Costal cartilage transplanted to repair deformities in the nose and elsewhere, easily survives, but it is always in complete apposition with the surrounding tissues, *i.e.*, it does not abut on dead spaces.

Moschcowitz (Annals Surg., Aug., 1918) urges removal of the *whole* costal cartilage which is diseased so that not even a trace of exposed cartilage is visible because cartilage exposure in an infected wound does not heal and practicaly always forms a sinus. If the disease and infection is slight the surgeon may do less excision and close the wound *without* drainage, especially without gauze drainage.

EXCISION OF TUMORS OF THE CHEST-WALL AND OF THE PLEURA

Malignant tumors of the thoracic wall are seldom attacked unless—*e.g.*, in the course of an amputation of the breast—a tumor is accidentally found to be attached to the thorax, a state of affairs not known before the operation

as begun. Parham has successfully removed a sarcoma of the chest-wall. Rixford ("Annals of Surg.," 1906, No. 1) has removed several carcinomata affecting the chest-wall. Deruginsky ("Annals of Surg.," 1906, No. 5) resected a portion of the chest-wall and the diaphragm for primary sarcoma of the pleura; the patient survived long enough to die from recurrence. Osteomata of the ribs ought, other things being favorable, always to be removed, because of the disastrous effects of their growth. The technique of the operation is very similar to that for the removal of tuberculous foci, and is along the following lines:

1. Make an incision all around the tumor, preserving as much skin as possible without cutting too near the disease.

2. Free the tumor from its surroundings, sacrificing all muscular tissue attached to it.

3. Subperiosteally divide all the ribs to which the tumor is adherent.

4. Note if the pleura is adherent to the tumor; if it is, then excise the adherent portions along with the tumor. Endeavor to avoid the *sudden* entrance of air into the pleura. Let the primary opening into the pleura be small, so that the air enters slowly; with a moist pad of gauze close the opening at intervals so that the conditions of internal and external pressure may have time to adjust themselves. As the pleural wound is enlarged, progressively pack gauze (sterile) into the pleural cavity. Many French surgeons advise wide opening of the pleura at once. The gauze packs shut off the rest of the cavity from the field of operation. Before the pleura is opened, warn the anesthetist to let the patient come out of deep anæsthesia. Coughing on the part of the patient is now desirable, as the violent distention of the lung helps to guard against dangerous pneumothorax. When the packing of gauze has been thoroughly done, violent disturbances of respiration do not continue long. After the tumor has been removed, the gauze must be withdrawn and the lung, which is generally "coughed into" the wound, is caught and fixed to the thorax with a few stitches. The *pneumopexy* is of special importance when part of the lung demands removal.

When a segment of lung is affected by the tumor, it, of course, is adherent to it, and thus it is easy to apply sutures all around the diseased area. Dollinger advises that pneumothorax be *slowly* produced the day prior to operation. Delageniere, after taking similar precautions, has operated for two hours in the open thorax without ill effect. The safety of slowly produced pneumothorax is evidenced by J. B. Murphy's work on phthisis pulmonalis. One of the many methods of operating under differential pressure may be adopted with good effect. After removal of all the disease, even perhaps of part of the diaphragm, close the wound with sutures, providing efficient drainage.

If so much skin has been removed that complete closure is impossible, and if there has been no suturing of the lung to the thoracic wall (pneumopexy), part at least of the gauze packing must be left in place until adhesions form. In every case the dressings must be liberal, air-tight, and left undisturbed as long as possible. Emmet Rixford recommends closure of the wound, under the above circumstances, by means of a flap taken from the abdomen or from the chest-wall of the opposite side. The lung soon expands, and air left in the

pleura rapidly disappears. (The preceding description of excision of tumors is largely taken from Karewski's admirable clinical lectures.) Rixford's paper on "Excision of Portions of the Chest-wall for Malignant Tumors" ("Annals of Surgery," Jan., 1906) substantiates in almost every particular the advice given above.

Pneumotomy.—Incision of the lung may be demanded for the removal of foreign bodies (see p. 292) or to provide for drainage in cases of pulmonary gangrene, abscess (whether tuberculous or pyogenic in origin), and large bronchiectatic cavities; also for the treatment of echinococcic cysts.

Operation is clearly indicated when the gangrenous area or the abscess is limited in extent, not multiple and is fairly accessible. It is usually considered improper to operate when the affected lung is widely diseased—*e.g.*, when there are large bronchiectatic cavities requiring drainage in both upper and lower lobes—but Th. Glück's experience shows that such may properly be attacked. The mortality of pulmonary gangrene treated non-surgically is 80 per cent.; treated surgically, 29 per cent. (McArthur).

G. Picot considers the mortality more than 75 per cent. without operation. When operation is performed early, some statistics show a mortality of but 17 per cent., but operation should only be undertaken where there is a single, circumscribed focus, and the patient has good resisting power. Picot considers "radiography preceded by radioscopy" to be the most valuable method of diagnosis, as exploratory puncture is fallacious and dangerous, while ordinary clinical tests have led to innumerable errors in localization.

The abscess is carefully localized by the usual methods of physical diagnosis. During the first week of the existence of gangrene the X-ray will show a shadow, but after this time putrefaction leads to cavity formation and the rays show a light area. After cleaning the skin over the site of the lesion it is commonly advised to explore in the following manner: The long and delicate needle of an exploring syringe is pushed in the direction in which the pus is believed to exist. The needle ought to be attached to the syringe by means of rubber tubing which has been divided and reunited by the interposition of a small glass bulb or tube. When the point of the needle has penetrated the lung to the suspected area, slight suction is made with the syringe. If any pus is present, it will be noticed in the glass placed in the tubing. If no pus is found, make the needle penetrate more deeply and repeat the suction. After every change in the position of the needle make the suction test with the syringe. When the piston of the syringe has been pulled out to its full extent, clamp the rubber tube, detach the syringe, push the piston down, attach the syringe to the tube, remove the clamp, and proceed as before. It may be necessary to push the needle in various directions before the pus is found. Having found the abscess by the above means, leave the needle *in situ* and proceed to expose the abscess.

Most experienced surgeons are afraid of infecting the pleura if they use the exploring needle in the above manner. Expose the affected area by subperiosteally removing a segment of one or more ribs, palpate the uninjured pleura, noting if motion and friction are absent and if it is grayish-yellow in color or infiltrated (signs of adhesions). McArthur advises that a fine

exploring needle be inserted for 1 cm. (⅜ inch) or less; if no adhesions are present the moving lung will cause the needle to rock; if adhesions are present the lung cannot slide on the parietal pleura, hence the needle will not rock. Note that this needle is *not* being used to explore for pus, but for adhesions. In the absence of adhesions it is advised *never* to use the needle to hunt for pus, because of the danger of infecting the pleura. If adhesions are present and palpation shows that solid—*i.e.*, diseased—lung is opposite the wound, either search for the pus with an aspirating needle (if pus is found leave the needle *in situ* until a free opening is made into the abscess) or at once penetrate the diseased area with a closed sinus forceps or with a Paquelin cautery heated to a dull red color. When the Paquelin cautery enters the cavity not only will pus flow, but smoke will be inhaled and exhaled. The principal advantage gained from the use of the cautery is that the walls of the channel made by it are sealed against absorption of the pus coming from the opened abscess. When the cavity has been penetrated, pass in the finger, explore and open secondary cavities, gently remove with the finger and gauze loose sloughs and débris. Do not break down any bands felt traversing the cavity, such may be blood-vessels. Do *not* douche the cavity; douching is well calculated to spread infection to other parts of the lung or to drown the patient. Do *not* use peroxide of hydrogen, the explosive frothing of this drug has all the evils of the douche. Introduce a *loose* gauze pack. If iodoform is used in the gauze let it be in feeble quantity, as it is liable to be rapidly absorbed and cause poisoning. Instead of gauze a split rubber tube—preferably covered with gauze—may be used. The tube unless soft or protected may cause pressure, necrosis and hemorrhage. A roll of rubber dam is probably the best drain.

If when the pleura is exposed the adhesions do not appear so strong as to be above suspicion, reinforce them by a few catgut stitches uniting the parietal and visceral pleura around the operative area. A patient of L. L. McArthur seemed to be progressing favorably when he began to cough severely, ruptured the pleural adhesions, infected the healthy pleura and died from the infection. It is a good plan to expose the pleura (excising the necessary segments of rib and also of intercostal muscles) under local anæsthesia. If the pleura is not adherent, the patient can easily force his lung into contact with the parietal pleura where it can readily be fixed by a few catgut sutures. A layer of gauze is now laid into the wound and the skin wound closed. After a few days the wound is reopened, the gauze removed and the pus sought.

Adhesions being present, "how shall we look for the disease area in the lung if it is not immediately before us? Circumscribed gangrene in the lung is always surrounded by a zone of infiltrated inflammatory tissue—nature's barrier to the progress of the disease—so with the knife and finger we will explore any indurated area that may be present. If this fails to reveal the disease we will use the exploring or aspirating needle, and, by passing it in various directions in the lung, judge from the feeling imparted to the fingers the character of the tissue the point is traversing, and also from the discharges the needle may bring away. If this gives us negative results it is best to discontinue any further search, and complete the operation by leaving a drainage-tube in the incision in the lung. All hope of evacuating the septic material need not yet be aban-

doned, for several cases have been reported where the pus has found its way to the drainage-tube within a few days, and the patient has ultimately made a good recovery."

If, after subperiosteal resection of the ribs, the pleura is found to be non-adherent, adhesions must be provided, otherwise as soon as the pleural cavity is opened a dangerous condition of pneumothorax obtains. The formation of adhesions may be stimulated by the application of irritants, such as chloride of zinc, to the outer surface of the unopened parietal pleura. This is rather a blind method of reaching the goal. Most surgeons proceed somewhat as follows: A fully curved needle, armed with a thick silk or catgut suture, is passed through the *unopened* pleura, made to pick up as large a *bite* of the lung and visceral pleura as is possible, and brought out again through the parietal pleura. Much gentleness must be exercised in tying the sutures as the pulmonary tissue is friable. From two to four sutures will generally be found ample to secure apposition of the two pleural layers. The parietal pleura is weak, therefore the sutures should catch other tissues as well. The sutures may be made to penetrate a large gauze pad (four thicknesses) laid on the outside of the chest, with an opening in the centre to permit of subsequent operation. The subsequent steps of the operation should be carried out, in the manner already described, after the lapse of a week.

Should the case be one of such urgency as to warrant incurring the extra risk, one must surround the diseased area by a row of interrupted "back-stitch" or interlocking sutures of catgut, uniting the parietes to the visceral pleura and lung. Do not take too deep a "bite" of lung with the needle. If pleural suturing is, from any cause, impossible, pack the pleural cavity as it is opened with gauze, as in the case of appendicitis; a smaller amount of gauze may suffice if the gauze packing is sutured with catgut into the pleural opening. It has been claimed that aseptic silk sutures applied to the non-infected pleura do not produce enough irritation to ensure the formation of effective adhesions. Silk sutures soaked in turpentine have been employed and found to be satisfactory.

After the pus has been evacuated, provision must be made for drainage. This is best done by leaving the wound wide open and packing with sterile gauze (iodoform gauze is liable to lead to poisoning). Rubber tubes may be used *if surrounded by gauze*. Tubes unprotected by gauze occasionally cause erosion of blood-vessels. Rubber dam is safe and efficient. When there is much loss of lung substance and there is not sufficient compensatory distention of the remainder to fill the resulting void in the thorax, the treatment must be similar to that of old empyema, viz., resection of an appropriate amount of thoracic wall. Lung wounds heal slowly and form but few granulations. Epidermization progresses from the skin alone; any growth of epithelium from divided bronchi leads to persistent fistulæ being formed. As soon as retraction or dragging inwards of the external soft parts ceases to progress satisfactorily, recovery may be hastened by the use of skin-flaps obtained in the neighborhood. If bronchial fistulæ persist, they may be closed by the application of the cautery. It must be remembered, however, that a persistent bronchial fistula may be,

in reality, beneficial in that it gives vent to discharges which would otherwise be retained and cause serious trouble.

In pulmonary hydatids C. E. Corlette places the patient in the semi-prone position (see p. 392) and excises about 10 cm. of two ribs including the periosteum. After incising the adherent pleura and exposing the adventitious capsule of the hydatid he anchors the latter by stay sutures and opens it. (In the *lung* the cysts are simple, *i.e.*, have no daughter cysts.) After evacuating the contents and mopping the cavity dry, he closes the opening in the pleura and capsule with sutures and closes the wound without drainage.

Pneumectomy.—Th. Glück, as early as 1882, elaborated the following method of excising one lung or part thereof. After opening the thorax by the removal of a segment from one or more ribs, grasp the lung with a clamp and pull a cone of it through the opening in the thorax. Apply a ligature behind the clamp, pull more of the lung through the wound and apply another clamp. Repeat this process of pulling the lung outwards with a clamp and ligating until the desired amount of lung is herniated or until the pulmonary root is reached. Cut away the lung distal to the last ligature, leaving about one inch of lung tissue protruding from the ligature. Suture the cut surface of the stump with interlocking stitches of catgut.

Glück ("Archiv für klin. Chir.," lxxxiii, 592) reports the following two cases on which he operated using the clamp and ligature method.

R. P., thirteen years, March 3, 1899. Multiple, fetid bronchiectasis of left lung. Resection of the sixth to tenth ribs. Resection of the upper lobe and total pneumectomy of the lower lobe of the left lung. Before operation an enormous amount of gangrenous material was discharged each day, after operation the discharge was not worth noticing and had no bad smell. The patient felt well, ran about and played with other children. In October, 1899, the thoracic wound was not completely healed; an operation was undertaken to close the wound and the patient died from unexpected collapse and heart failure (Herztod). Autopsy showed chronic interstitial and parenchymatous myocarditis. The bronchiectatic process had been completely removed and the lung wound had healed. Heidenhain has resected the lower lobe (left) of a lung—the seat of bronchiectatic cavities—with success.

Glück's second case is most important. The patient suffered in 1896 from lymphangitis migrans and thrombo-phlebitis of the left and subsequently of the right lower extremities. In May, 1897, there were left-sided pulmonary infarcts; the left pleura was twice punctured and large amounts of exudates removed. Recovery in July, 1897. In April, 1899, septic phlegmon extensor aspect of right forearm, which was nearly healed in July, when there was a chill with 41.5° (Fh. 106.7) of fever. Pyemia developed requiring radical operation for right axillary abscess and phlegmon of chest-wall (twice); evacuation abscess on sternum; transverse drainage, right ankle-joint; operation, left pleural empyema (twice). In spite of extensive resection of ribs and evacuation of pus from the pleura elastic fibres were found in the putrid discharges. January 3, 1900, there were bloody sputum, dyspnœa and extreme weakness. The thorax was opened widely, the enormously thickened and degenerated pleura was resected and the whole lower lobe of the left lung was removed with

the aid of clamps and ligatures. During the after-treatment the patient could breathe freely and comfortably through the wound when his mouth and nose were closed. Healing was completed in nine months. Nine years after operation the scar is on a level with the skin; and in spite of the extensive resection of ribs there is neither deformity of the thorax nor spine. The diaphragm has pushed upwards and the upper lobe of the lung is vicariously expanded. In pneumectomy closure of the divided bronchi is always a difficulty. Willy Meyer has overcome this difficulty by separating the peribronchial vessels from the bronchi and ligating them, then by crushing the stiff bronchi with an angiotribe he is able to treat it by ligature and inversion sutures like the stump in appendectomy.

Extrapleural Resection of Lung (Tuffier, International Congress, London, 1913).—Suitable in cases of apical tuberculosis.

Open the thorax widely in the second intercostal space but do *not* incise the pleura. Separate the 2nd and 3rd ribs with suitable retractors or spreaders.

With the finger gently separate the parietal pleura from the chest wall until the whole apex of the lung *plus* the corresponding parietal pleura, is freed.

Ligate the lung beyond the disease and cut away the affected apex. Let the stump drop back into the thorax. Close the chest without drainage.

EXPOSURE OF THE PERICARDIUM AND OF THE HEART

Operations on the Orifices of the Heart.—The investigations of Carrel and his disciples have achieved so much that no great boldness is required to prophesy that the surgeon will, before long, aid in the therapeutics of certain lesions of the cardiac orifices. The following paragraphs are based on the publications of Carrel and Tuffier (Annals Surg., July, 1914; La Presse Méd. 4, March, 1914). The lesions which ought to be susceptible to surgical aid are:

1. Mitral stenoses. In these the *free borders* of the valves are alone affected, the valves themselves, the cardiac muscle and the peripheral circulation remaining for a long time in good condition.

2. Aortic stenoses may occupy three positions, viz., valvular, supra-aortic and infra-aortic; of these only the valvular are likely to be amenable to surgical intervention. Valvular lesions are characterized by adhesions, thickenings and deformations of the borders of the valves, forming a simple indurated ring. Exceptionally the lesion affects the fibrous circle at the base of the valves.

3. Stenoses of the pulmonary artery are similar to those of the aorta, but the artery itself is dilated *above* the stenosis, this being due to a loss of elasticity in its walls.

4. Congenital tricuspid stenoses show similar characteristics and are peculiarly suited to operative treatment because of the integrity of the heart.

Although an orificial lesion is anatomically suitable for operation, and although the cardiac muscle and vessels are sufficiently healthy to give hope of success, yet operation is not justifiable unless the disease by its persistence and progressiveness inevitably will early give rise to grave or mortal troubles. Such indications for operative treatment are rare.

A pure mitral stenosis in a young subject with a healthy heart, in which the trouble is progressive as shown by functional symptoms, and which will cer-

tainly be fatal, is a proper case for operation. Some slowly advancing aortic stenoses with hypertrophy of the left ventricle may also be considered mechanical lesions susceptible of treatment by enlargement of the orifice.

Stenoses of the pulmonary artery when isolated and independent of any other cardiac malformation are almost always soon fatal from pulmonary tuberculosis. It is not likely that lesions causing insufficiency of the cardiac orifices will be suitable for operation.

Special Dangers in Cardiac Operations.—(*a*) Injury to the coronary vessels. The coronary vein may be tied with impunity but *not* near its main trunk.

Injuries to the peripheral parts of the coronary arteries are well borne. Near the origin of the arteries even a prick with the finest needle gives rise to serious symptoms. Ligation of the artery proximal to its bifurcation is always promptly fatal.

(*b*) The only bleeding which is difficult to arrest is that from the left auricle. This is due to the thinness and friability of its walls.

(*c*) The entry of air into the right ventricle with consequent pulmonary "air embolism" is not of the gravest moment, but its entry into the left ventricle leads to fatal embolism in the coronary arteries. Air in the heart is removed by aspiration.

(*d*) The danger zones of the heart are:

1. The coronary vessels between their origin and their first divisions must not be touched.

2. The inter-auricular septum is so sensitive that the least injury to it causes arrest of the heart in diastole.

3. Section of the auriculo-ventricular septum causes immediate arrest of the left ventricle in diastole. In the auriculo-ventricular region near the left border of the heart there is a sort of vital node, injury to which is dangerous or mortal, even a slight pressure here excites an extrasystole.

4. At the junction of the middle and upper thirds of the anterior longitudinal groove there is a point at which mechanical irritation can cause sudden arrest of the heart.

5. The motor stimulus of the heart originates at the base of the right auricle near the venous orifices. This is a very dangerous zone.

For cardiac operations, anæsthesia is produced with ether given by the Meltzer-Auer method. The thoracic cavity is opened, the operative field is walled off with "oil silk and cotton knotted compresses," the pericardium is opened and the heart exposed. A Doyen forceps (jaws protected by rubber tubing) is used to compress the pedicle of the heart. The heart is not dislocated but the pericardial wound must be large enough to give free access. One blade of the clamp is introduced into the pericardium under the pedicle and directed from the right to the left side by the finger. At this moment (without any compression) over-ventilate the blood by the Meltzer-Auer method and then rapidly close the clamp and without a moment's delay proceed with the operation. The pedicle may be clamped for two and a half (2½) or three (3) minutes with safety.

Exposure of the Aortic and Pulmonary Orifices.—For the pulmonary orifice make the incision on the left side of the artery at the junction of the anterior and

left sigmoid valves. The incision is made by means of scissors of unequal blades, the longer blade being pointed. With this the vessel is punctured before the cut is made. Exposure may be effected by a cut in the artery alone; usually in experiments the incision was about 4 cm. long, half of which was on the pulmonary artery and half on the ventricle. Here the branches of the coronary artery are small and can be cut without danger.

For the aortic valves make the incision on the right side of the aorta between the mouths of the right and left coronary arteries, generally directly above the middle of the right valve.

When the operation has been completed, suture the wound with a continuous suture of No. 1 Chinese silk sterilized in vaseline. Introduce through the line of suture a curved cannula connected with an aspirator and suck out the air from the heart. Remove the pedicle clamp.

What operations may be performed on the valves? Carrel has cauterized the valves and has dilated the orifices with the finger. Tuffier performed this operation on a patient with amelioration of symptoms. Sir Lauder Brunton, Harvey Cushing and others have divided valves by special long delicate tenotome-like instruments introduced at a distance. Tuffier remarks: "if one divides the valvular diaphragm without resecting a portion of it, it is necessary to fix one of the lateral valves to the ventricular wall with a silk suture in order to prevent coalescence and secondary reunion of their borders." Such operations may be named internal valvulotomy. External valvulotomy with patching of the vessel is being done very successfully in animals without clamping the pedicle of the heart.

Carrel thus describes the operation: "A piece of vena cava or of any other vein, preserved in cold storage, was cut into the shape of a rectangular flap about 2.5 by 2 cm. This flap was put on the anterior part of the pulmonary artery in such a way that its middle corresponded about to the pulmonary orifice, the lower part being on the surface of the ventricular wall. Then the two lateral sides and the upper side were fixed to the surface of the heart and the pulmonary artery by means of a continuous suture. The longer blade of the scissors was introduced underneath the lower side of the flap and the sharp point was introduced into the lumen of the pulmonary orifice. Then the wall was cut and dark blood escaped between the surface of the heart and the lower part of the flap, but the hemorrhage was immediately controlled by the index-finger of the operator which compressed the flap down on the wound. The fourth side of the flap was next fixed to the surface of the heart by a continuous suture. The flap immediately appeared distended by dark blood, and it was assumed that in case of stenosis of the pulmonary orifice this operation would permit of a dilatation of that orifice. The operation was performed without stopping the circulation of the heart. The operation would be rendered easier by clamping the pedicle of the heart for a very short time. Although this is a more dangerous procedure, it is probable that it would simplify the operation." In their experiments on dogs Carrel and Tuffier opened the thorax by an incision from the sternum (internal mammary vessels ligated and divided) to the posterior part of the axilla, in the second or third intercostal space. The second space was chosen when access to the great vessels was desired.

It is not necessary to resect any ribs. The pleura is incised and the ribs eparated by a mechanical self-retaining retractor. Once pneumothorax is stablished respiration by means of the Meltzer-Auer apparatus is easy. The leura is protected by compresses of fine vaselinized silk.

H. M. W. Gray (Birkbeck and Lorimer, Brit. Med. J., Oct., 1915) has emoved a bullet from the cavity of the right ventricle. The patient died our days after operation from multiple pulmonary infarction. The operation vas performed under morphine and local anæsthesia (eucaine 1 per cent.; potas- ium sulph. ¼ per cent.; adrenalin). The pericardium was widely exposed by eflecting a large flap of sternum and costal cartilages. The right pleura was pened and the lung collapsed causing respiratory trouble and anxiety for bout one minute. The pericardium was freely opened. During palpation f the heart a beat was missed occasionally when the upper and back part of the interventricular septum was touched. The heart was held forwards by a stitch passed through the muscle of the right ventricle. Palpation showing the bullet to be loose in the ventricle it was coaxed away from the neighborhood of the coronary vessels and grasped between the finger and thumb. Two stitches were inserted into the muscle wall over the bullet, a half inch incision made and the bullet extracted. The sutures were tied and an extra running stitch applied. The pericardial cavity was freed of blood clot, filled with saline solution to expel air, and sutured. The right pleural cavity was filled with saline solution and the pleural wound sutured. While the wound was being closed the chest was aspirated.

Scalone (Ref. Internat. Abstract of Surg., June, 1919, 471).—As a result of experiments comes to the following conclusions:

"A projectile remaining in any part of the heart affects its functioning even if the patient does not feel any disturbance.

"Extraction does not in all cases lead to recovery from the disturbances, especially when anatomic alterations have taken place.

"From the operative point of view it is necessary to distinguish projectiles embedded in the myocardium from those free in the heart cavities. Projectiles in the myocardium which do not cause disturbances ought to be left alone. Operation might increase the anatomic alterations due to the projectile, the result being a diffuse myocarditis, a lesion of the nerves or the production of adhesions.

"Extraction is indicated in the case of projectiles in the myocardium which cause disturbances not referable to anatomic alterations but to severe nerve lesions not otherwise susceptible to treatment.

"In view of the danger of embolus, extraction is indicated in the case of projectiles free in the circulatory system.

"In every case the advantages of a cardiotomy ought to be carefully weighed against the dangers and results to be derived from non-intervention."

Statistics of 16 cases of projectiles in the heart wall treated surgically give 14 recoveries and 2 deaths while 23 cases in which no operation was performed all recovered. In spite of these figures Duval considers that the ultimate dangers arising from the presence of a projectile in the wall of the heart justifies its removal (Soc. de Chir., Paris, 1919).

Pericardiocentesis.—This operation is indicated both as a means of diagnosis and of treatment. For diagnostic purposes we may use an exploring or hypodermic syringe provided with a long needle; for purposes of treatment an aspirator is required. When the pericardial effusion is non-infective, a cure may be obtained by simple paracentesis. In performing this operation, the fluid must be withdrawn slowly and the suction stopped, temporarily, whenever there is any pulmonary or cardiac distress. It is unnecessary and imprudent completely to evacuate the fluid. The usual site for introducing the aspirating needle is in the fourth or fifth intercostal space, one inch to the left of the sternum. A better position is in the sixth intercostal space immediately to the left of the edge of the sternum. This last position gives the greatest security against injury to the internal mammary artery, to the pleura, and to the heart itself.

G. Blechman (Internat. Abstracts, July, 1914) disapproves of the above methods as being likely to puncture the heart or pleura. He recommends Marfan's method. Introduce a lumbar puncture needle in the middle line immediately below the xiphoid cartilage. Pass the needle obliquely from below upward for 2 cm. along the posterior surface of the sternum, then somewhat obliquely backwards passing into the gap in the sternal insertion of the diaphragm so as to penetrate the pericardium at its base. Blechman used this method successfully seventeen times on one patient.

In cases of pericarditis with effusion, even suppurative, Weil and Loiseleur (La Pr. Med., Dec. 28, 1916) recommend aspiration of the fluid and injection of air equal in amount to the volume of fluid withdrawn. Repeated aspirations and injections may be necessary, and may be aided in their execution by the use of the fluoroscope to detect isolated pockets of effusion. When producing pleural pneumothorax, one can well introduce the air at the same time that any present effusion is being aspirated but in producing pericardial pneumothorax one is compelled to aspirate first and then pump the air in. Weil and Loiseleur write "one injects ordinary atmospheric air without any special filtration After having removed the liquid with Potain's aspirator, one reverses the stop-cock on the pump and so can inject air. . . . To measure the quantity of air being injected one counts the number of strokes of the piston. (The capacity of the pump is about 30 c.c.)"

When there is an infective exudate in the pericardium, operation is clearly indicated. The same is true in all cases of wounds in the cardiac region when there is marked respiratory distress with cyanosis or there is collapse with anæmia and corresponding changes in the pulse, accompanied by the physical signs of pericardiac effusion (Kocher).

Many methods have been devised by which to expose the pericardium and heart: of these, Ware gives an excellent account in the "Annals of Surgery" (October, 1899), but almost all of them, *e.g.*, those of Podrez, Niuni, etc., assume that one desires to expose the whole pericardial sac in every case and that a lesser procedure will never be efficient. Such operations consist in the formation and reflection of large flaps consisting of the skin, muscles, costal cartilages, and sternum. They require much technical skill for their performance. Wounds of the pericardium and heart call for ***immediate attention***, and

extremely difficult and unnecessarily complicated method should be ught.

Pericardiotomy. *Method A.*—(1) Make an incision down to the bone from ie middle line of the sternum outwards towards the left side, at the level and llowing the line of the sixth costal cartilage. If required, the incision may ttend to the left mammary line. (2) Separate the perichondrium and all the ft parts from the sixth costal cartilage and excise the cartilage. This exposes he triangular muscle of the sternum with the mammary vessels, which are igated if necessary. Divide the tendinous insertion of the triangular muscle nto the sternum. The dense, glistening pericardium now lies exposed, and if drainage alone is required, it may be opened and the operation is complete. If more room is required: (3) From the sternal end of the horizontal incision cut upwards in the midsternal line to the desired extent (usually to the level of the second rib). (4) Separate the periosteum and soft structures from the sternum to the left of the median line. Divide the fifth, fourth, and third left costal cartilages at their insertions into the sternum. (5) Through the horizontal wound push the exposed margin of pleura outwards. Gradually lift up the fifth and even the fourth and third costal cartilages, slowly and gently pushing back the pleura from their deep surface. (6) After separating the flap from the pleura, fracture or divide the costal cartilages in the flap, at their junction with the corresponding ribs. When this is done, the flap can be completely reflected. (7) Split the pericardium along the sternal margin and laterally along the fifth interspace. This gives access to the heart from the auricles to the apex of the ventricles. If more room is desired (8) excise a sufficient portion of the sternum by means of ronguer or bone forceps.

The pericardium being open, wipe away blood-clots which may be present; search for and suture with catgut or silk any cardiac wounds. Do *not* include in the suture a coronary artery. Close the pericardial wound with or without drainage. Suture or drain any pleural wounds which may be present. Don't waste time by trying to evacuate thoroughly blood from the pleural cavity; nature may generally be relied upon to attend to that better than can the surgeon.

Method B. Median Thoraco-abdominal Pericardiotomy.—Duval and Barasto (La Pr. Med., Aug. 29, 1919).

Step 1.—Make a median incision from the level of the third rib to a point midway between the ensiform cartilage and the umbilicus. The incision penetrates to the bone and to, but *not* through the peritoneum, in the linea alba.

Step 2.—With a knife detach the recti-muscles from the ensiform. Divide the attachments of the diaphragm to the posterior surface of the ensiform exactly in the middle line. Push two fingers upwards behind the ensiform keeping them in contact with the posterior surface of the bone until the level of the third rib is reached. This separates the pericardium from the sternum. When pulling the fingers out separate them slightly so as to push the two pleuræ from the sternum and costal cartilages.

Step 3.—Divide the sternum along the middle line with strong bone forceps up to the level of the third rib. Opposite the third rib divide the sternum transversely. Separate the two parts of the sternum with strong hooks.

Step 4.—Open the peritoneum in the middle line. Open the pericardium immediately above the diaphragm and a little to the left (the pleuræ are well separated here).

Step. 5.—Note the diaphragm forming a partition between the peritoneum and pericardium. Divide this partition up to the coronary ligament. While doing this gently support the inferior border of the heart. With the hooks lift up the two segments of the sternum. This is like opening a book and the ventricles, auricles, large vessels and the anterior and posterior surfaces of the heart are widely exposed without delivery of this organ, without traction or torsion and the two hands of the operator are free to carry out any necessary maneuvres on the heart under guidance of the eye.

Step 6.—Suture the diaphragm from the abdominal side. Close the abdomen. Replace the sternal flaps *without* bone suture. Suture the skin. This operation has been used in the successful extraction of a bullet from the pericardial segment of the inferior vena cava. Barbier and Goujon (Ref. Internat. Abst. of Surg., June, 1919) successfully extracted a projectile from the posterior wall of the heart midway between apex and base by the thoraco-abdominal route.

Tully Vaughan ("Journ. A. M. A.," Feb. 6, 1909) has collected statistics of 150 patients operated on for wounds of the heart and comes to the following conclusions:

"1. There is no longer any question as to the propriety of the operation, since 35 per cent. of the patients recover, compared with 15 per cent. (according to Holmes and Fisher, 1881) of recoveries after non-operative treatment—a gain of 20 per cent.

"2. The mortality is practically the same that it was twelve years ago, when the operation was first introduced, and it behooves the surgeon to study the matter and find a means of improvement.

"3. The two great causes of death are hemorrhage and inflammation of the pleura or pericardium. Probably little more can be done than has been done to prevent death from hemorrhage, but inasmuch as more than half the patients who survive twenty hours have infection.

"4. There is room for great improvement in preventing infection. Besides the observance of strict asepsis the question of opening the pleura and of drainage of pleura or pericardium acting as predisposing cause of infection is of the greatest importance.

"5. As a rule, therefore, the pericardium and pleura should not be drained."

The principles of operation on pericardiac and cardiac wounds may be summarized as follows: (1) Cleanse. (2) Enlarge the external wound. (3) Freely expose the injured pericardium by excision of portions of the ribs and sternum or by the median thoraco-abdominal route. (4) Attend to hemostasis. (5) Open the pericardium and remove effused blood. (6) Attend to cardiac wounds if present. (7) Close the wounds in pericardium and in pleura if such be ptesent. (8) Close external wound with or preferably without drainage.

In suppurative pericarditis Mintz's operation seems very practical and not difficult ("Zent. für Chir.," No. 30, 1912). Make an incision along the lower

edge of the seventh costal cartilage. Separate the lower edge of the cartilage from its connections but do *not* open the peritoneum. With a periosteal elevator separate the cartilage from its posterior connections. Divide the cartilage near the sternum and also at a suitable point externally. The anterior surface of the cartilage is *not* denuded. Reflect upwards the flap thus formed and so expose the pericardium. Blechman recommends Larrey's method of left subchondral incision as giving easy access to the pericardium through the epigastrium especially in children. This operation seems practically the same as Mintz's.

Cardiolysis or Pericardiolysis.—When the heart becomes adherent firmly to its pericardial pouch, and that in turn to the sternum, etc., a distressing and very fatal series of conditions arise. In such cases the heart fails, because with every systole it must needs pull in along with it the osseous thoracic wall. No heart can long stand the strain of such excessive overwork. Two methods of operative treatment have been advised.

Delorme's Operation.—(A) The operation is particularly indicated (*a*) when there are adhesions of rheumatic origin with dilatation, hypertrophy and orificial lesions and *a fortiori* without such lesions. (*b*) When there are tuberculous adhesions specially as localized lesions, analogous to those of the other serous cavities, joints, etc. (*Delorme*).

The Operation.—Expose the pericardium by excising the fifth or sixth costal cartilage from the sternal insertion outwards for from 6 to 8 cm. If the adhesions correspond to the origin of the great vessels, excise like portions of the fourth and third cartilages. So far the operation is exploratory. If the adhesions are solid, extensive but separable, reflect a flap of thoracic wall corresponding to the fourth, fifth, and sixth cartilages and having its base external. Great care is required to avoid opening the pleura. The parietal pericardium having been exposed incise it through the whole length exposed. Separate the adhesions with the fingers or blunt pointed scissors. Do any cutting necessary at the expense of the pericardium and under guidance of the eye. Leave inaccessible and very resistant adhesions alone. If the adhesions are too intimate for separation be content with section of the pericardium along its anterior diaphragmatic attachments from the left sternal border to the apex of the heart avoiding injury to the left phrenic nerve.

(B) *Pericardiolysis.*—Petersen and Simon have successfully (three cases) carried out an operation suggested by L. Brauer. The object of the operation is *not* to free the heart from the adhesions, but to render these harmless. It is unnecessary to describe the steps of the procedure, which consist in the reflection of a flap of skin and muscle, the exposure of those ribs and that part of the sternum which impede, by their rigidity, the heart's action, and the excision of these bony or cartilaginous structures to any extent required. It is advised to excise the periosteum of the posterior surface of the sternum, lest new bone be formed. This is the most difficult step in the operation. Very careful hemostasis is essential, because, when operated on, the patient is usually very weak, but his circulation soon regains strength, and hence hemorrhage and the formation of a hematoma may supervene. Petersen advises that we should begin

the operation by excising three ribs, and then, if *necessary*, remove a portion of the sternum also.

P. Lecène ("Archives des mal. du Coeur, des Vaisseaux et du Sang," Dec., 1909; "La Presse Méd.," April 23, 1910) has collected twenty cases of pericardiolysis performed by various German and English surgeons where there was no operative mortality and the results were notable and durable. After operation the heart became regular, dyspnœa ceased and the various forms of visceral stasis gradually became less, suffering disappeared and a relatively active life became possible.

Alexander Morison ("Lancet," July 4, 1908 and Nov. 20, 1909) advised thoracostomy (pericardiolysis) in a case of excessive cardiac hypertrophy in aortic valvular disease associated with severe and frequent attacks of pain but with *no* costo-pericardial adhesions. Mr. Stabb operated for Morison and the results was most satisfactory. The reasoning of Morison in his paper is most convincing. (See Douay's remarks, p. 322.)

Milton's Method of Exposing the Anterior Mediastinum (H. Milton, Lancet, March 27, 1897).—Make a median incision from the cricoid to the ensiform. Expose the trachea. Carefully divide all the attachments to the sternal notch—while doing this make the knife absolutely hug the bone. If necessary nick the sternal attachments of the sternomastoids. Pass the finger gently behind the sternum from above downwards as far as possible. Either beginning at the sternal notch or at a trephine opening made through the body of the sternum near the ensiform cartilage split the sternum vertically with chisel or saw or both. Separate the ensiform from the body of the sternum. With strong sharp hooks separate the two halves of the sternum for about 1 cm. This space permits the division, under guidance of the eye, of obstructions to a further separation of 5 or 6 cm. This permits free exploration of the anterior mediastinum and through it of the other mediastina. The bone wound is easily closed by wires passed through holes bored in the bone.

Lilienthal (Surg., Gyn. & Obst.) successfully removed a mediastinal thyroid by Milton's method.

In performing Milton's operation it is not always necessary or proper to divide the whole of the sternum; division of the manubrium is often sufficient.

Milton's method will prove of service in operations upon the thymus. Kocher exposes the upper mediastinum by reflecting outwards a trap door flap consisting of skin and manubrium sterni.

Exposure of cervico-mediastinal space may be necessary in the treatment of lesions of the lower neck behind the clavicle or of the upper anterior mediastinum. Such lesions include aneurisms of the great vessels arising from the arch of the aorta.

Le Fort's Method. *Anatomy.*—The clavicle articulates with the sternum and first rib. The sterno-hyoid and sternothyroid muscles are inserted into the *posterior surface* of the clavicle, sternum, costo-clavicular ligament, cartilage of the first and even of the second rib. Thus there is a thick buttress of muscle and aponeurosis between the bones and the vessels, nerves and pleuræ.

The Operation.—Place patient in the dorsal decubitus with a long pillow between the scapulæ to make the shoulders fall backwards.

Step 1.—From the level of the first intercostal space make an incision 10–12 cm. (4–4¾ in.) long, upwards in the median line. This incision penetrates to the bone where it is over the sternum, and through the skin higher up. From the lower end of the vertical incision make a cut outwards along the middle of the first intercostal space until the deltoid is reached. Split the pectoralis major and expose the intercostal muscles.

Step 2.—Expose the anterior surface of the sterno-mastoid. With finger or closed scissors separate the posterior surface of the sterno-mastoid from the anterior surface of the sterno-hyoid and sterno-thyroid, thus exposing the insertion of these latter muscles into the posterior surface of the sternum and sterno-costo-clavicular articulation. Hugging the bone divide these insertions as well as the insertion of the deep cervical fascia. This is the only delicate step in the operation and a strongly curved rugine is a great aid in effecting it. Continue the separation of the soft parts downwards and outwards from the posterior surfaces of the sternum, the inner end of the clavicle and the first costal cartilage until the finger reaches the posterior surface of the first intercostal space.

Step 3.—With the fingers raise the tissues in the supra-sternal space and divide them. This means division of the anastomosis of the anterior jugular veins which is of little importance and they are the only vessels sacrificed during the operation.

Divide the upper part of the manubrium sterni on the middle line down to the level of the first intercostal space. Bone cutting forceps are suitable for this purpose.

Step 4.—Thoroughly clear the inner portion of the first intercostal space both on its anterior and posterior surfaces. With a rugine or elevator free the border of the sternum between the first and second ribs until the blade of a bone cutting forceps can be insinuated behind the sternum without injury to the internal mammary vessels. Divide the sternum horizontally until the vertical line of section is met.

Step 5.—Raise the mobilized segment of sternum along with the clavicle and first rib and continue the separation of the soft parts posteriorly. As the flap is raised divide the muscles of the first intercostal space bit by bit to a point near the axillary vein.

The flap can now be retracted or reflected upwards and outwards without impeding the subclavian or axillary vessels and without injury to the internal mammary vessels.

The large vessels of the neck and the mediastinal organs are hidden by the infrahyoid muscles, the cervical fascia, the remnants of the thymus, much connective tissue and the pleura. The trunk of the innominate vein is recognizable. Further exposure of vessels and organs may be secured through the cervical or the mediastinal route in the latter with or without opening pleura.

(*a*) *Cervical Route.*—Incise the deep fascia along the external border of the sterno-hyoid. This gives easy access to the deep planes and vessels of the neck. Remember that the fascia is inserted into the innominate vein and avoid injuring that vessel.

(*b*) *Extra-pleural Mediastinal Route.*—Penetrate the connective tissue and

retract the pleura. It is easy to expose the origin of the carotids, subclavians, innominates, the vagus, convexity of the arch of the aorta, the recurrent laryngeals, trachea and œsophagus.

(*c*) *Transpleural Route.*—Open the pleura at the first intercostal space. Especially on the left side it is very easy to reach the origin of the great vessels which are clearly visible through the parietal pleura. This route has the advantage of avoiding exposure of the vagus, cardiac and phrenic nerves.

Step 6.—Replace the flap. Suture of the bone is optional. Suture the intercostal space, the pectoralis major and the fascia. Close the wound.

R. Le Fort (Rev. de Chir., LIII, No. 5 and 6, 1917) has studied the best methods for the removal of foreign bodies in the mediastinum and finds the anterior transpleural route the best both for the anterior and the posterior mediastinum.

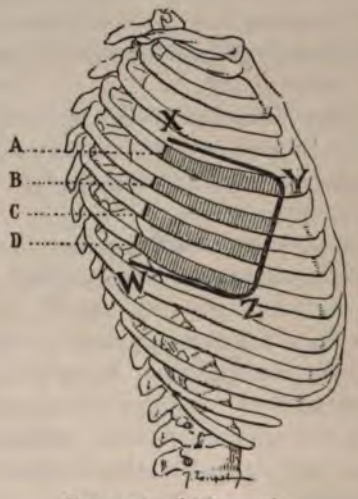


FIG. 436.—(*Schwartz.*)

If the foreign body is deeply situated at the level of the third rib posterior to the sternal border, maximal excision of the third rib with maximal retraction by means of rib spreaders gives a wound 16 cm. long by 8 cm. wide, *i.e.*, an area of 85 cm.^{2} While a flap containing the 3-4-5 ribs can be made with its upper border 16 cm. long, lower 20 cm., inner 11 cm., *i.e.*, an area of 198 cm.^{2} is exposed.

In the lower chest the best exposure is given by means of a flap (Delorme's). Wide access may be obtained to both surfaces of the heart, to the aorta (ascending, transverse, descending) from its origin to the diaphragm, to the pulmonary vessels, the trachea and the œsophagus, in a word, to the whole mediastinum from clavicle to diaphragm and from the sternum to the spine, between the third and twelfth dorsal vertebræ.

The exposure is made as follows:

Choose the appropriate ribs to be mobilized.

At the points *A*, *B*, *C*, *D* on the chosen ribs divide the bones subperiosteally (Fig. 436) (Chir. du Thorax, Schwartz). Trace the flap *XYZW*. Open the pleura along the lines *XY* and *WZ*. Divide the ribs, intercostal structures

pleura along the line *YZ*. Reflect the flap outwards. When the intra-cic operation is finished, replace the flap and suture.

OPERATIONS ON THE POSTERIOR MEDIASTINUM*

s the type of operations on the posterior mediastinum, one may take of Nassilov, a description of which was published in 1888 and in 1899 by anov. The following description closely follows that of Nassilov: Place patient in the ventral or semiventral position. Make an incision at least e inches in length along a line parallel to the vertebral column, and four er-breadths from it. From each end of the vertical cut make a horizontal sion towards the spine. Reflect towards the spine the musculo-cutaneous thus delimited. Resect the exposed portions of ribs subperiosteally. This uires great care because of the danger of puncturing the pleura. Should

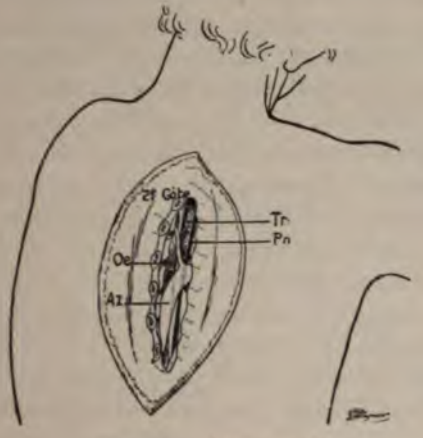


FIG. 437.—(*Schwartz.*)

pleural wound be inflicted, suture it immediately. The ribs should be cted close to the spine, as this gives most valuable room. The superior tion of the œsophagus (above the arch of the aorta—Bryant) is accessible r excision of portions of the third, fourth, fifth and sixth ribs on the side; the inferior portion after resection of three or more of the lower ribs on *right* side. Attend to hemostasis. Carefully separate with the fingers the terior portion of the pleura from the remnants of the excised ribs attached he spine. When operating on the left side, push the lung forwards with palm of the hand and fingers; this exposes the thoracic aorta, to the right hich lies the œsophagus. The œsophagus may be recognized by palpation, if necessary by a sound being passed into it from the mouth. By blunt ection with a grooved director separate the loose cellular tissue which en-passes the aorta, the large and small azygos veins, the pneumogastric es, and the thoracic duct. The œsophagus is now disengaged from its oundings.

The accompanying figure 437 shows something of the anatomical diffi-

* also section on posterior bronchotomy, p. 1244, and Le Fort's method, p. 340.

culties of the operation if the first rib is not divided. Resection of the first rib permits much greater exposure of the mediastinum.

If the operation is for the removal of a foreign body from the thoracic gullet, the œsophageal wall is caught with two forceps and divided between them over the body, which is removed with forceps. The œsophageal wound may or may not be sutured; certainly free drainage of the wounded posterior mediastinum is a necessity. Small, apparently localized, cancers of the œsophagus may possibly be excised after exposure in the above manner. Inflammatory lesions of the posterior mediastinum may be exposed by Nassilov's operation and subjected to proper surgical treatment.

PART III.—THE ABDOMEN

CHAPTER XXXII

LAPAROTOMY; CELIOTOMY; ABDOMINAL SECTION

POSITION OF PATIENT DURING OPERATION

For most laparotomies the dorsal decubitus is used. When a patient lies on his back on an operating table there is always a strain exercised on the lumbo-sacral region, which strain subsequently manifests itself by greater or less pain in the back. This is avoided by supporting the small of the back by a small pillow, or better by so arranging the table that the thighs are slightly flexed on the pelvis and the knees moderately bent. This latter posture is particularly valuable in that it relaxes the abdomen and decreases intra-abdominal pressure. On a properly constructed table it does not interfere with obtaining the Trendelenburg posture and, according to Emmet Rixford, it does away with the necessity of adopting the Robson position in operations upon the biliary passages. Rixford has devised a table which enables the upper trunk to be slightly elevated thus increasing the benefit to be obtained from flexing the lower extremities.

During operations on the lower abdomen good exposure of the operative field may be obtained by elevating the lower end of the table, preferably with simultaneous slight flexion at the hips and knees (Trendelenburg's position). An inclination of 45° may be used.

When Trendelenburg's position is used the patient should be prevented from sliding along the inclined table by means of shoulder braces and never by letting the knees be flexed over the foot end of the table, which increases intra-abdominal pressure objectionably.

During operations in the region of the gall-bladder the intestines may be kept out of the way by placing a sand-bag about five inches in diameter under the back, opposite the lower dorsal vertebræ. (Robson's position.)

METHODS OF OPENING THE ABDOMEN

The patient, anesthetized, is placed on the operating table. The limbs and chest are well protected with blankets. The operating-room and table are well heated. The field of operation is cleansed and surrounded by sterile cloths or towels. A good incision must (*a*) give proper access to the disease to be investigated and treated and ought to be capable of any necessary enlargement; (*b*) be capable of easy and efficient closure with the least possible danger of subsequent hernia or paralysis.

A longitudinal incision in the linea alba is classical, is easily enlarged and injures no important vessels and nerves. Unfortunately hernia is a frequent

sequel as only thin layers of aponeurosis can be coapted. To avoid this objection the cut is usually made slightly to one side of the linea alba, the sheath of the rectus is opened, the muscle either split or pulled aside and the tissues behind are cut. A longitudinal cut above the umbilicus is difficult to close because of tension. The fibres of the transversalis muscle are continued internal to the outer edge of the rectus and acting through the posterior sheath of the rectus makes suture of this structure very difficult and insecure.

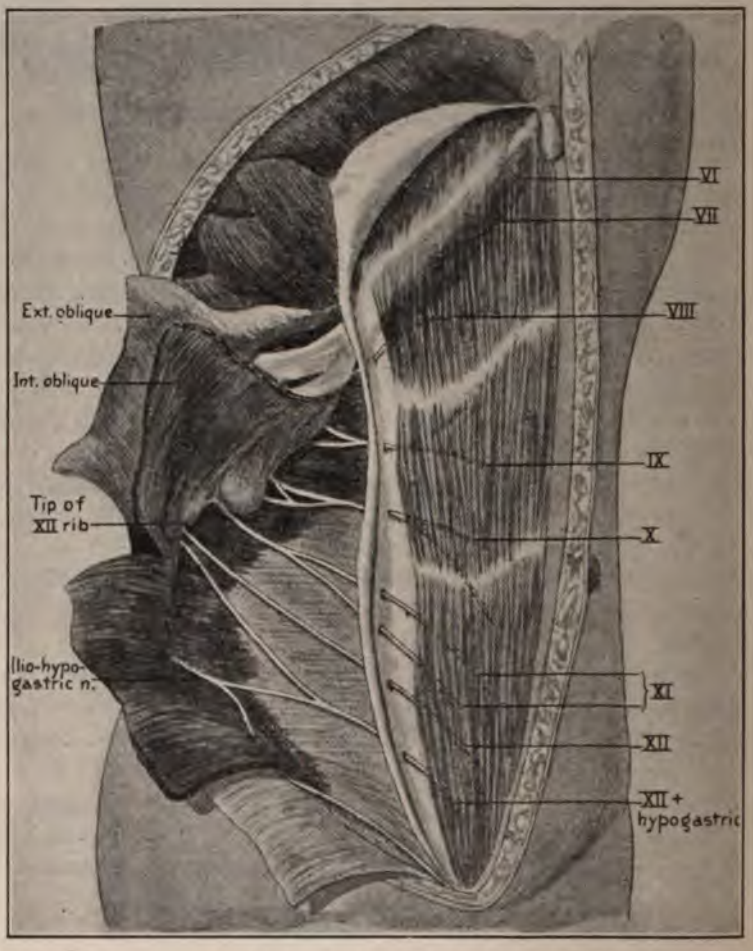


FIG. 438.—(*Pannett. By permission of the British Journal of Surgery.*)

Vertical incisions through the rectus or at its outer margin destroy its nerve supply to a greater or less extent and ought to produce an objectionable paralysis of that muscle. Practically one finds few cases of serious paralytic lesions following the long vertical wounds so commonly used in surgery of the gall-bladder and appendix, but when they do occur the surgeon wishes he had spared the nerves. For certain pieces of intra-abdominal work incisions like that of McArthur and McBurney for appendectomy are ideal as in them the differen

flat muscles and aponeuroses are split one after the other in the direc-
ir fibres and the nerves are not cut.

one remembers that the aponeuroses of the abdominal wall are the
the flat muscles (oblique and transverse), and that these are inserted
fellows on the opposite side, one must realize that a so-called longi-
cision is *physiologically* transverse, in that it cuts the aponeuroses
more or less transversely. This applies particularly to division of
sheath but not to that of the recti muscles. Transverse division
ectus muscle particularly
umbilicus does not seem
1 the muscle greatly, it
rely adds a new *inscriptio*
The so-called transverse
)f the abdominal wall are
)re or less oblique or curved
in parallel to the course of
s (Fig. 438). The addi-
short vertical cut in the
.e is often useful and does
ially add to the difficulty

lower abdomen an incision
lan of Pfannenstiel is often
l in gaining access to the
. curved transverse incision
downwards) divides the
aponeurosis; the aponeuro-
ected from the recti and
upwards and downwards,
re separated and the peri-
opened. Closure is easy
secure. (For articles on
incisions, see Kocher
slehre; Rockey, N. Y. Med.
'. 4, 1905; Maylard, Brit. Med. J., ii, 1907; Assmy. Beitr. z. klin. Chir.,
Boeckmann, St. Paul Med. J., June, 1910; Sprengel, Archiv f. klin.
; Fritz König, Zent. F. Chir., April 20, 1912; Farr., Journ. Lancet,
912; C. A. Pannett, Trans. Surg. Sect. R. Soc., Med., Oct. 14, 1914.)

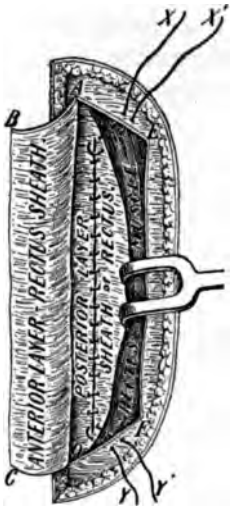


FIG. 439.

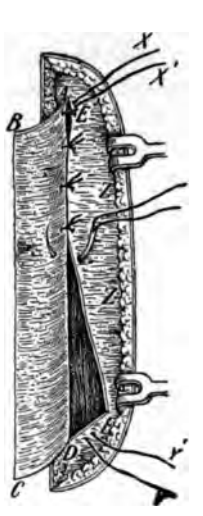


FIG. 440.

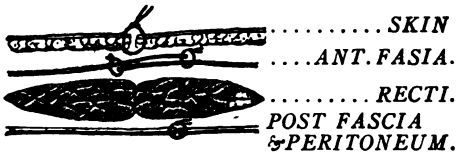


FIG. 441.

FIGS. 439, 440 AND 441.—Chevrier's incision.

edian Incisions.—In the middle line, either above or below the
, make an incision through the skin and subcutaneous tissues. The
the incision varies according to circumstances, but to begin with is
out three inches. In the linea alba divide the firm structures con-
he *essential* belly-wall. As a rule, hemorrhage will be trifling and
isregarded, but if any vessels bleed amazingly, apply clamps or liga-
re opening the peritoneum. Pick up a small fold of peritoneum in
d cautiously make a very small incision through it. When satisfied
peritoneum is [redacted] the peritoneal wound in a

hemostat and by crossing the forceps, temporarily, close the belly until the hands can be once more rinsed, first in an antiseptic solution and then in water or salt solution. Enlarge the peritoneal wound; introduce the finger to explore. Enlarge the incision with scissors, if such enlargement be necessary to permit of further operative procedures.

If it be necessary to enlarge the incision beyond the umbilicus, cut around that structure generally to its left side, or even excise it, since it is not suitable for suturing and it is impossible thoroughly to cleanse it.

(B) **Chevrier's Incision.**—Incise the skin in the middle line and expose the anterior layer of the rectus sheath. Reflect the skin to one side so as to lay bare the fascia for distance of ½ to ¾ inch from the middle line. Incise the fascia about ½ inch from the middle line and reflect the fascial flap A, B, C, D, the pedicle of which corresponds to the middle line (Fig. 439). Reflect the flap a little beyond the middle line so as to expose the median border and a little of the opposite rectus muscle.

Retract the rectus so as to expose the posterior layer of the rectus sheath. Incise the sheath. In closing the wound proceed as follows: Suture the wound in the posterior layer of the sheath. In order to keep this line of suture from sliding towards the middle line, introduce at each end the sutures XX′ and YY′ which penetrate the anterior layer of tne sheath, the rectus muscle and the upper and lower ends of the sutured wound. Tie sutures XX′ and YY′ only after suture of the anterior layer of the sheath.

Suture the edge (EF) of the defect in the anterior fascia to the base (AD) of the flap (A, B, C, D, Fig. 440). Tie the sutures XX′ and YY′. Suture the edge (BC) of the flap A, B, C, D, to the surface of the fascia along the line Z, Z, Z (Fig. 440). Close the skin wound.

The result of the procedure is shown in Fig. 441.

(C) **Lennander's Method.**—(Kammerer; Battle; Jaboulay.) Make a vertical incision a short distance to the right or left of the median line, exposing the anterior surface of the rectus. Incise the anterior layer of the rectus sheath. Retract the inner edge of the rectus outwards, exposing the posterior layer of its sheath, and incise that layer. Open the peritoneum. Note that the rectus muscle itself is neither incised nor split, and hence its nerve-supply is not injured in the slightest. In closing the wound, remember to suture each layer of the rectus sheath separately (Fig. 442). A similiar incision may be made about three-fourths of an inch internal to the outer edge of the rectus, the sheath opened, the muscle retracted inwards, and the abdomen penetrated. This outer incision is very commonly used for exposing the vermiform appendix but it of course may injure the nerves.

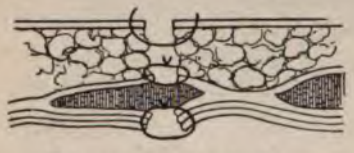


FIG. 442.—Rectus incision.

(D) **Vertical Incision through the Rectus.**—This incision is excellent. Make a vertical incision to one side of the median line down to and through the anterior layer of the rectus sheath. Split the rectus muscle by blunt dissection. Divide the posterior layer of sheath and open the abdomen.

(E) Vertical Incision at the Outer Edge of the Rectus.—This requires no ecial description.

(F) Transverse Incision.—As has already been stated the general direction these incisions is transverse, but as a rule they are really oblique, curved or ven angular. The direction of any part of the cut depends principally on the ourse of the nerves. In the region of the gall-bladder the incision usually uns more or less parallel to the costal margin, though when dividing the rectus nuscle the author prefers to cut at right angles to its fibres. In exposing the tomach the incison may be curved (convexity upwards), both recti being di-vided, or it may be transverse, one or both recti being divided in whole or in part. The incisions when prolonged beyond the recti ought always to split the fibres of the external oblique and not cut them transversely to their course. Such incisions are of the gridiron type like the McArthur-McBurney incision. In the lower abdomen the incisions are usually curved with convexity downwards.

As an example of transverse incision the method may be taken by which the author often exposes the right iliac region in cases of chronic appendicitis when considerable exploration is necessary. Make an incision in the inter-spinous line from the linea alba to the outer edge of the rectus and expose the rectus sheath. Introduce and loosely tie two lines of interrupted catgut stitches transversely through the rectus sheath and underlying muscle. Divide the sheath between these lines of sutures. Cut through the rectus muscle deliber-ately so as to expose the deep epigastric vessels. It is almost always necessary, to ligate and divide these vessels. Open the peritoneum. If it is necessary to enlarge the wound laterally, this is easily done in the gridiron fashion. If median enlargement is required, the other rectus muscle may be divided without ill result. Closure of the above wound is very easy and secure. The method is not suitable in the presence of acute infective lesions.

It is specially above the umbilicus that transverse incisions are very useful.

(G) Oblique Incisions.—In the lower half of the abdominal wall, when it is desired to operate remote from the median line, incisions are recommended running obliquely from above downwards and inwards—*i.e.*, in the direction of the fibres of the external oblique muscle. Such avoid division of important motor nerves and permit of splitting instead of dividing the external oblique muscle. (See Chapter on "Appendicitis.")

METHODS OF CLOSING THE ABDOMEN

The great object to be attained in closing the abdomen is the prevention of subsequent hernia. In the attempt to gain this end, surgeons have adopted a vast number of methods of suture. A study of the annexed diagrams (Figs. 443 to 450) will explain the suture methods more clearly than any printed description. The buried sutures uniting peritoneum or fascia are best intro-duced with full curved or short straight needles, and may be catgut, silk, silk-worm-gut, or silver wire. The writer prefers some form of catgut, either mildly chromicized or iodized. Kocher thinks silk the only proper material. In the Johns Hopkins clinic silver wire is used. Other surgeons prefer silk-

worm-gut, tendon, aluminium-bronze wire, etc. When properly used, ea material does good work. Some surgeons, *e.g.*, Jonnesco, object to the u of absorbable sutures, of non-absorbable buried sutures, and yet desire to clo the abdominal wound in layers. For this reason they have devised more

FIG. 443.

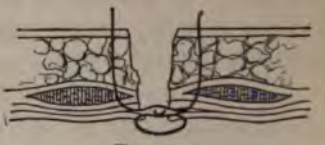


FIG. 444.

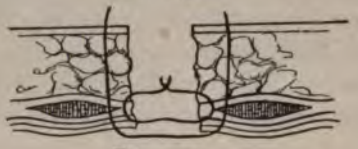


FIG. 445.

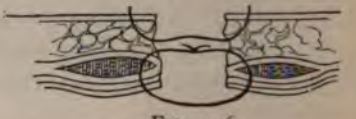


FIG. 446.

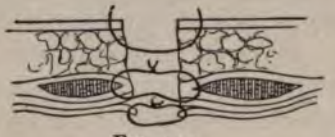


FIG. 447.

FIG. 448.

FIG. 449.

FIG. 450.

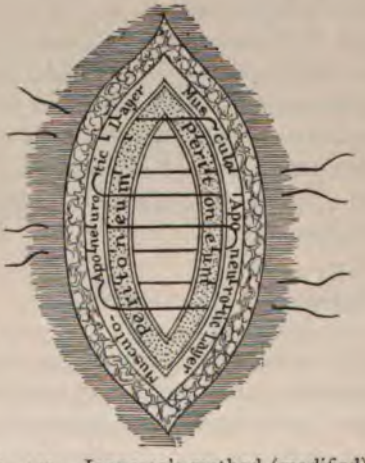


FIG. 451.—Jonnesco's method (modified).

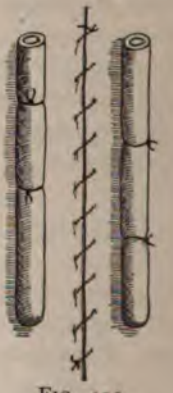


FIG. 452.

less complicated means of suturing, so that they can remove the stitches w they have served their purpose (Figs. 451, 452, 453, 454).

In not extremely rare instances a wound does not heal by the time cat sutures are absorbed. This peculiarity has caused a number of disast

is wise to reinforce the catgut sutures by two, three or four silkworm-gut uation stitches.

The inexperienced surgeon, after completing a prolonged operation on an usted individual, sometimes forgets that it is better to have a post-operative ia in a living patient than a perfectly closed wound in a corpse. Under circumstances it is wise to put in as few stitches as possible, and these in uickest manner possible.

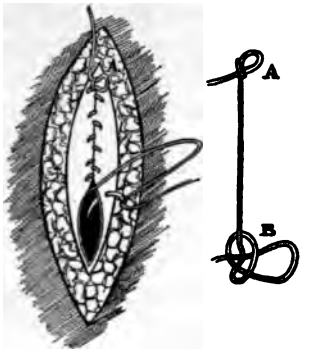


FIG. 453.—Davison's method.

A. Slip-knot to prevent suture being pulled through the tissues. The free end of the suture is left projecting from the wound, and when pulled upon unties the slip-knot and so permits extraction of the suture. B. Slip-knot tied when suture is in place. Untie the same way as A.

FIG. 454.

Continuous sutures fixed by pad of gauze at A.

When drainage has been used, it is good practice to place sutures in position r the closure of the opening left by the removal of the drain and tighten and e these subsequently.

When drainage is necessary it is often wise to establish it through a special ncision or stab, and then close the primary wound completely. The means sed to provide drainage is liable to cause trouble in the main wound.

DRESSINGS

After completion of the operation, cover the wound with a number of pads of sterile absorbent gauze; over these place a liberal quantity of sterile absorbent cotton. Keep the dressings in place with a binder, or preferably by strips of adhesive plaster. Abundant dressings, snugly applied, support the intra-abdominal blood-vessels and prevent the patient from bleeding into his own veins after large tumors have been removed. Under ordinary circumstances the author has discarded the use of all dressings contenting himself with painting the wound daily with alcohol or a weak solution of iodine. A sterile towel may be thrown over the abdomen, it rarely remains in position.

TREATMENT AFTER LAPAROTOMY

Return the patient to bed. A small pillow may be placed under the head, but for a short time the head must not be elevated. If there is much pain give an efficient dose of an opiate, as suffering and restlessness are greater evils than are the noxious effects of the opiate itself. Rectal instillations of salt solution are of great value in relieving thirst and in providing the patient with

needed liquid. An enema consisting of soda bicarb. ℥iv in ℥viii of water is valuable immediately after operation. If the rectum is irritable, hypodermoclysis is often valuable. Washing the mouth with water is of value in relieving thirst and is very grateful to the patient. A. J. Ochsner stimulates secretion of saliva by letting the patient use chewing gum or hold some object like the stone of a plum in his mouth. The increased flow of saliva lessens thirst and lessens the dangers of parotitis. One must remember, however, that a too protracted increased flow of saliva may ultimately increase the thirst. As soon as nausea passes off, begin giving small doses of water, preferably hot, by the mouth. If this is well borne the patient may soon be permitted to drink two or more pints per day. Orange juice is greatly appreciated by most patients, and to it a little egg albumen may be added with advantage. In most cases liquid nourishment may be given sparingly in 12 or 24 hours after operation. The author in recent years has become more and more liberal in permitting food to, but *not* forcing it upon his patients after laparotomy.

If "gas pains" give trouble an enema of soap suds gives relief. When there is difficulty in expelling flatus a rectal tube should be introduced and left in place. Wetherill long ago urged that post operation catharsis be discarded. The writer has adopted that wise man's views and usually leaves the bowels at rest for some days unless special indications calling for their evacuation arise. If it is necessary to move the bowels pituitrin is of great value.

A few years ago many surgeons considered it essential to keep patients in the dorsal position for a long time after laparotomy. This is cruel and injurious. Permit the patient to lie in whatever position is comfortable so long as it does not exert tension on the wound. After certain operations—*e.g.*, those on the stomach and those for peritonitis—the above rule may not prevail. After operations on the upper half of the abdomen it is permissible to allow the patient to sit up early, as the sitting posture does not increase tension on the wound to any great extent. After operations on the lower half of the belly, the sitting posture means increased tension on the wound and hence increased risk of hernia, therefore the author usually in clean cases adheres more or less closely to the rules formulated for the after-treatment of hernia operations. When drainage has been instituted the Fowler position may be imperative. The tendency of surgeons is towards letting the patients sit up and move about at an early date, even a very early date, after operation, but to the author it appears risky as tension on a wound insufficiently solidified is well calculated to cause hernia. When the abdomen has been opened by the grid-iron method of McArthur and McBurney, the above remarks do not apply. The avoidance of tympany during convalescence is of great importance for the same reason, viz., the tension it exerts on the wound.

The stomach tube is of enormous value after laparotomy. If nausea is prolonged the stomach ought to be washed out. If there is any evidence of beginning acute dilatation of the stomach lavage is imperative. Half an hour before passing the tube in a nervous patient it is well to give ⅛ gr. morph. hypodermatically and immediately before the operation the fauces should be sprayed or swabbed with cocaine.

GASTRO-INTESTINAL OPERATIONS

Before describing the individual operations performed on the gastro-in-
ıtinal canal it will be convenient to consider the means at our disposal for
ɐventing the escape of its contents from an incised gut and of closing in-
ıtinal openings by means of sutures. Some special means of suturing
ll be described later, along with the operations
r which they were devised.

Preparation of a Loop of Gut for Incision.—
ith the finger and thumb express the contents
the selected portion of gut either upwards or
wnwards so as to leave that portion empty.
ɐvent the return of the contents to the loop
gut by appropriate clamps, applied above
ıd below. When available, the best clamps
e the fingers of an assistant exercising pressure

FIG. 455.—Murphy's clamp.

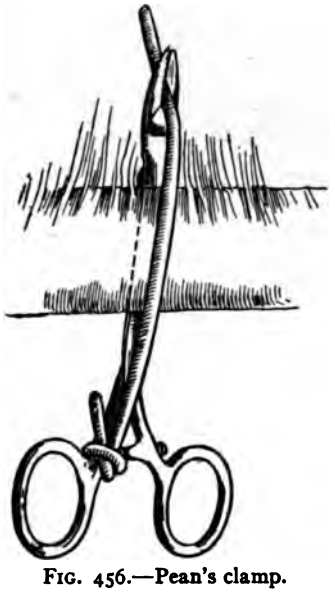


FIG. 456.—Pean's clamp.

ı the gut. The objections to this are that the fingers are liable to take up too **uch room,** and that the hands of the assistant become so fatigued that he **ın give** but little assistance during the rest of the operation. If plenty **help is at hand,** of course the latter objection loses its weight. Murphy's clamps (Fig. 455) are excellent. It is entirely unnecessary to protect the blades of this clamp with rubber tubing.

Pean has suggested a most convenient intestinal clamp (Fig. 456) and one which is always ready. To the proximal side of the catch of an ordinary hemo-

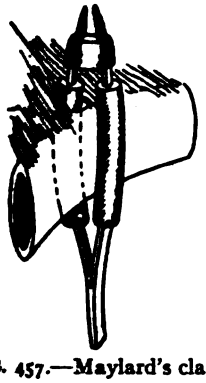


Fig. 457.—Maylard's clamp.

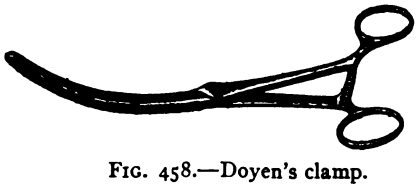


FIG. 458.—Doyen's clamp.

ıatic forceps tie the end of a soft-rubber catheter or piece of drainage-tube.
ass the point of the forceps behind the gut and through the mesentery close
o the gut. Open the forceps. Place the free end of the rubber tubing over
he front of the gut; stretch the tubing and catch it in the jaws of the forceps.

The result is that the gut is clamped by the rubber in front pressing towards the forceps behind.

Passage of intestinal contents may be stopped by tying around the gut strips of gauze or pieces of coarse silk or catgut. Of course, before they can surround the gut they must perforate the mesentery. Do not tie such materials tightly as little pressure is necessary and much is injurious.

Maylard extemporizes an excellent clamp by covering the blades of a dissecting forceps with rubber tubing. When the blades have been made to

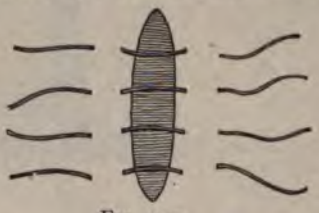


FIG. 459.

FIG. 460.

FIGS. 459 AND 460.—Lembert suture.

grasp the intestine, their points are kept together by a segment of tubing slipped over them (Fig. 457).

All the above clamps are good for the prevention of escape of intestinal contents, but certain clamps with long blades (protected by rubber tubing) not only serve this purpose but control hemorrhage and may be employed as handles by which the segments of gut can be held steadily in a position convenient for suturing, etc. Such clamps are: Doyen's (Fig. 458), Hartmann's, Moynihan's, Harrington's, Scudder's, etc. A clamp good for gastro-enterostomy is good for most intestinal work.

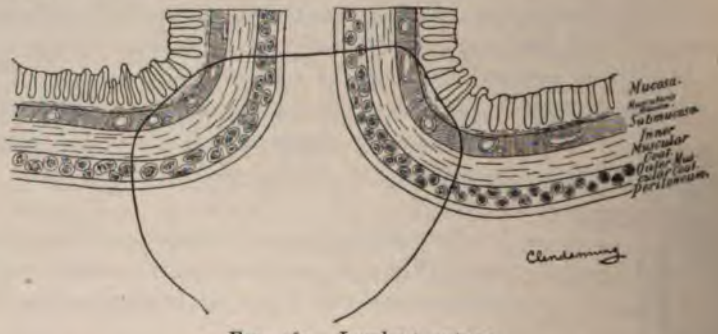


FIG. 461.—Lembert suture.

Intestinal Suture.—The most common material for intestinal suture is fine twisted silk—preferably black. The disadvantage of silk is that when wet it is difficult to pass through the eye of a fine needle. To avoid this difficulty a sufficiency of needles should be threaded before sterilization is begun. The author generally uses fine waxed silk or linen. Fine chromicized or tanned catgut is excellent. The best needles are the ordinary seamstress' needles, about one and a quarter inches in length. Various curved needles (without any cutting-edge) are useful and can be obtained in any good instrument store.

The intestinal wall consists of the following tunics: the serosa, the musculosa, the submucosa, and the mucosa. The submucosa is the firm, thin tunic which is used in making sausages. It provides the most reliable hold for a suture.

Lembert Suture.—This is the basis of almost all methods of intestinal suture. Its aim is to close an intestinal wound by turning the cut edges inwards and bringing the serosa of one side into apposition with that of the other side. Halsted has shown that it is wise to include the submucosa in the stitch. When a *not* too sharp needle is introduced through the serosa and musculosa, its advance is easy, but when it reaches the submucosa, a slightly increased resistance is perceptible. It is said to be easy to pick up some of the submucosa on the point of the needle without penetrating the mucosa. The author has frequently endeavored to insert Lembert sutures involving the serosa and musculosa alone, but they always tore out; the picking up of a few fibres of the submucosa without letting the needle pass into the mucosa seems to be an "iridescent dream." The blood-vessels lie in the submucosa, and in suturing unless the thread is passed under the vessels (*i.e.*, nearer the mucosa) the stitches will exercise no pressure upon them and thus serious hemorrhage may, and sometimes does occur. In inserting sutures the surgeon should see to it that *each stitch embraces firm tissue and will not cut out, and that each stitch goes under any visible vessel in its track.* If these two rules are observed good results will be obtained no matter if the thread does pass through the deeper layers of the mucosa. The author knows of one or more cases in which the operator took special pains to insert the sutures through the serosa and musculosa alone and nearly lost the patient from hemorrhage. The introduction of the suture is sufficiently shown in Figs. 459, 460, and 461.

FIG. 462.—Mattress suture. (*Monod and Vanverts.*)

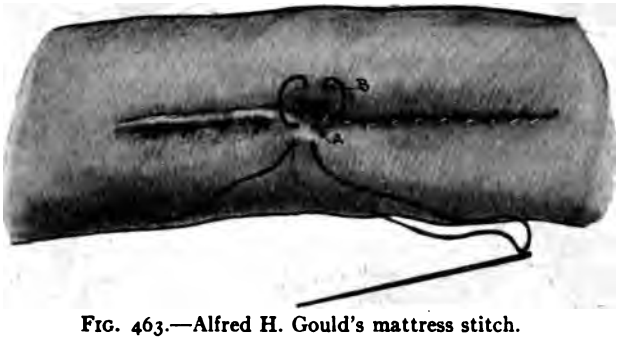


FIG. 463.—Alfred H. Gould's mattress stitch.
Note that the loop is reversed. This results in the rolling in of the peritoneum on the side of the loop—B drawn to A.

FIG. 464.—Dupuytren's suture. (*Esmarch and Kowalsig.*)

Halsted's Quilted Suture.—This is in principle identical with Lembe The suture is introduced after the **U** fashion (Fig. 462). Gould's matt suture with reversed loop is admirable (Fig. 463).

Dupuytren's suture (Fig. 464), or continuous Lembert, can be easily quickly applied, and when properly used, is a most excellent proced In America it is curious to notice that most eastern operators use the in rupted suture, while the Westerners favor the continuous. The res seem as good whichever method is employed; hence the continuous be

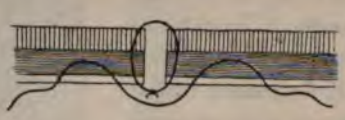


FIG. 465.

FIG. 466.

FIG. 467.

FIG. 468.

FIG. 469.

FIG. 470.—Cushing's suture.

FIG. 471.—Gely's suture.

the easier to apply, it seems to the author to be the better. It is importa to observe the blood-vessels running towards the wound in the gut, and pass the needle under such, so that when the edges of the sound are invert by the tightening of the sutures, these constrict the vessels and so preve hemorrhage. If one fears that a continuous suture will act as a purse-str and cause contraction, one may obviate this danger (if danger it be) by occ ionally interrupting the suture by fixing it with a knot (interrupted continu suture).

everal methods of closing an intestinal wound by different layers of suture been devised. Some of these are illustrated in Figs. 465, 466, 467, 468, 469.

hrough-and-through Sutures.—When closing a wound or uniting divided of gut there is often considerable hemorrhage and some danger of the line embert sutures becoming infected by intestinal contents. To control orrhage nothing is better than to unite the edges of the wound with a inuous stitch of catgut penetrating all the thickness of the gut-wall. This of suture is at once covered and hidden by a row of Lembert or Dupuytren res, and serves to protect the latter from infection. Cushing's and Gely's ods of suture are sufficiently explained by Figs. 470 and 471.

CHAPTER XXXIII

THE STOMACH

Exploratory Operation on the Stomach.—At least one day prior to opera- thoroughly wash out the stomach with warm water. Repeat this lavage ediately before the operation. Be careful to empty the stomach com- ely. If the stomach has been for a long time much dilated, do not empty luring the first lavage. Under these circumstances preparation should ume several days. If the organ is suddenly or rapidly cleaned, tetany ery liable to develop. In dehydrated patients, *i.e.*, those who pass not e than 500 c.c. of urine in twenty-four hours, it is of vital importance to ply fluid to the tissues. This may be accomplished by means of Murphy's toclysis or by giving hypodermically from 40 to 60 ounces of saline solution diem for several days before operation.

When diseased, the stomach almost always lies at a lower level than in lth, hence the incision need not be so near the ensiform cartilage as might magined from a study of normal anatomy.

Having opened the abdominal cavity, introduce the finger and palpate stomach and its surroundings. This is often sufficient for diagnosis. t is not sufficient, pull the stomach into the abdominal wound, surround ith warm pads, and inspect the anterior gastric wall. If a pyloric stenosis uspected, invaginate a part of the stomach-wall with the finger so that finger penetrates and palpates the pylorus. Gentleness must be employed. xploration of the posterior wall is necessary it may be exposed through eral routes. (1) Gastro-hepatic route. Tear a hole through the gastro- atic omentum. This permits finger exploration but does not give free ss. (2) Trans-mesocolic route. This is the same route as used in posterior ro-enterostomy and is efficient. (3) Gastro-colic route. Make an incision llel to the greater curvature through the gastro-colic omentum being careful void injury to the gastro-epiploic vessels. This method requires the liga- of a number of branches of the gastro-epiploics but gives excellent access to stomach. Care must be taken lest the vessels in the mesocolon be acci- ally injured. After completing the active operation suture the wound in omentum or stitch the divided omentum to the stomach. (4) Intercolo-

epiploic route. Separate the great omentum from the transverse colon by cutting an opening in the serous membrane of the transverse colon at its junction with the great omentum and separate the omentum from the colon (see p. 404). This gives good exposure of the stomach, duodenum and pancreas. Pauchet and Sherwood Dunn strongly advise the inter-colo-epiploic route in the treatment of posterior gastric and duodenal ulcers and in bullet wounds of the posterior wall of the stomach. If it is desirable to explore the interior of the stomach, *e.g.*, for ulcers, pack the abdominal cavity around the stomach with warm gauze pads. It is universally advised to count the pads before beginning the operation. This is a good rule. A rather better precaution against losing and leaving a pad in the belly cavity is to have 6 inches of soft tape sewed to each pad, and as the pads are introduced into the belly to let the tape emerge from the wound and be anchored by a hemostat. The tapes emerging through the wound are never in the way. The pads used should be large. Those 24 inches long by 6 inches wide are good. The writer makes it a rule never to place a pad in the abdomen without an anchor affixed, and never to use pieces of gauze for sponging inside the cavity unless they are held in sponge forceps. These rules are simple, and hence efficient. Masson (Jour. A. M. A., May 31, 1919) advises that a metal ring be placed round the base of the tape and firmly stitched both to the sponge (gauze pad) and to the tape. If any doubt regarding the sponge count arises a roentgenogram will clear it up at once.

Have an assistant pick up a fold of the anterior wall of the stomach. Incise this fold in a direction at right angles to the long axis of the organ. If there is fluid in the stomach and its walls are not weakened too much by disease, introduce a blunt tube and empty the viscus. Introduce the finger into and palpate the stomach. Retract the edges of the wound and inspect the interior. In doing this a cylindrical rectal speculum provided with a diaphragm and 2½ inches long by 1½ in diameter is of great aid and permits inspection of the duodenum through the pylorus. Close the gastric wound by sutures of catgut involving the whole thickness of the wall; this row of sutures to be inverted or buried by a series of Lembert or continuous Lembert stitches of fine chromic gut. Close the abdomen. Return the patient to bed. Keep him warm.

Thirst, and later hunger, may be relieved by warm water or nutrient enemata. If possible, do not give anything by the mouth for at least twelve hours, and then only water. Remember that the danger arising from giving drink or food by the stomach in such cases is really *not* from its leaking through the wound, but from vomiting being set up by its presence, and also from its stimulating effect giving rise to peristalsis, etc.* Hypodermoclysis or rectal instillation of salt solution is of inestimable value in these cases. It is desirable that the stomach rest until repair is advanced. If there is much pain, morphine in an efficient dose should be given. If possible to avoid the use of morphine without cruelty, do so, but when its employment is decided on, administer in one dose enough to insure the effects desired.

* Possibly too much weight is given to the dangers of early feeding. Roux is extremely heterodox, feeding his gastro-enterostomy patients with almost anything they desire as soon as they desire it.

Exploratory operations are strongly indicated "in cases of rapidly de-oping cachexia and emaciation with the symptoms of chronic gastritis l absence of HCl. Tentative treatment should not be prolonged over ee weeks. It is not near so serious a fault to have caused the opening a stomach and found nothing operable, as to permit a case to continue l find out at the autopsy only that it was a circumscribed carcinoma, the noval of which might have prolonged life for years." (Hemmeter, "Dis. Stom.," p. 358.)

Operating for Cardiospasm.—Mikulicz observed a number of cases in ich the patients suffered severely from œsophageal obstruction due to uscular spasm at the œsophageal-gastric junction. When milder means treatment failed he obtained complete cure by opening the stomach, pass-g an instrument like a glove stretcher into the œsophagus through the omach and thus forcibly stretching the muscle at fault. Brünig has opened e blades of the Mikulicz's forceps as much as 2¼ inches (6 cm.) with ex-llent results.

Dilatation by means of air or water bags introduced through the mouth has ractically entirely displaced the Mikulicz operation. See Plummer, "Journ. . M. A.," Aug. 15, 1908.

Gastrostomy.—The object of gastrostomy is to make a convenient fistula nto the stomach through which nourishment can be administered. Œsoph-geal stenosis is *the* indication for the operation, hence we have usually to lo with emaciated and weak patients. The simplest method of operating s the worst. It consists in performing an exploratory gastrotomy and sutur-ng the stomach wound to that in the parietes. The objection to the above method is that it permits a constant escape of the gastric juices. All the other methods of gastrostomy are attempts to avoid the above-mentioned fault.

(A) *Gastrostomy with Formation of Sphincter* (Hartmann; Terrier; Jaboulay, etc.).—By percussion and palpation define the lower edge of the liver in the epigastrium.

Step 1.—Make a vertical incision 1 to 1½ inches to the left of the median line, beginning at the lower edge of the liver and running downwards for about 2½ to 3 inches. Divide the anterior layer of the muscular sheath and split the rectus itself, but do *not* yet divide the posterior layer of the sheath.

Step 2.—Retract the wound inwards and thus expose the posterior layer of the rectus sheath and divide it along with the peritoneum near the median line.

Step 3.—Introduce the finger and pass it up under the left lobe of the liver to the portal fissure, and follow the gastro-hepatic omentum to the lesser curvature of the stomach. (Maylard, "Surgery of the Alimentary Canal.") This avoids all danger of mistaking colon for stomach. Pick up the anterior wall of the stomach and pull a cone of it through the wound. Close all the excess of peritoneal wound.

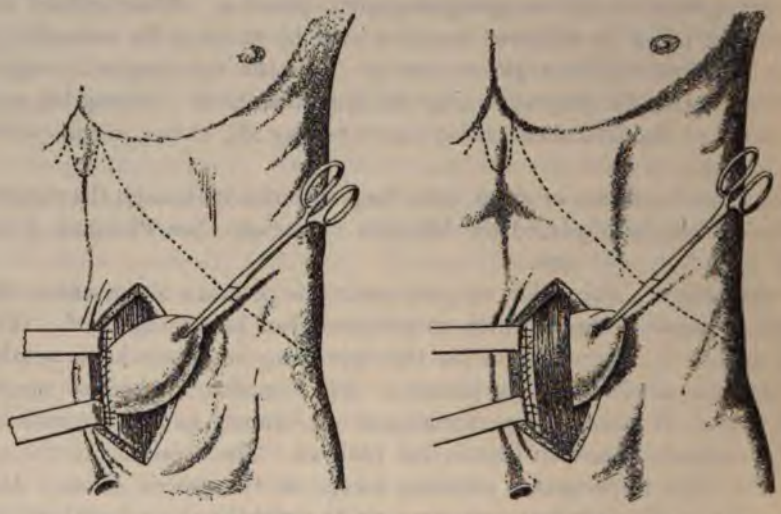
FIG. 472.—Gastrostomy.

Step 4.—Remove retractors and permit the rectus muscle to resume its normal position (Fig. 472).

Step 5.—Close all excess of abdominal wound and suture the protruding cone

of stomach to the skin. Open the protruding portion of stomach and introduce a soft catheter into it.

Steps 1 and 2 may be varied as follows: Divide the anterior layer of rectus sheath along the line of the skin-incision; retract it inwards, *i.e.*, to the right; retract the whole rectus muscle outwards, exposing and dividing the posterior layer of sheath and the peritoneum near the median line; pull out the cone of stomach; split the rectus muscle along the line of the skin-incision and separate the internal portion from its posterior layer of sheath; pull the cone of stomach through the bridge of muscle thus formed and suture to the skin (Figs. 473 and 474).



FIGS. 473 AND 474.—Hartmann-Terrier-Jaboulay gastrostomy. (*Monod and Vanverts.*)

(B) *Frank's Operation.—Step* 1.—Beginning near the lower edge of the liver, make an incision downwards and towards the left, parallel to and one inch below the left costal cartilages. Length of incision, 2 to 3 inches.

Step 2.—Through the incision pull out a cone of stomach from as near its cardiac end as is possible without too much tension.

Step 3.—Make a second skin-incision, about 1½ inches in length, parallel to the first and situated over the left costal cartilages. Undermine the skin between the two incisions and pull the cone of stomach through the tunnel thus formed. Suture the stomach to the skin at the second incision.

Step 4.—Close the first wound without exerting too much pressure on the cone of stomach which traverses it. Open the apex of the stomach cone. The result is an oblique valvular fistula.

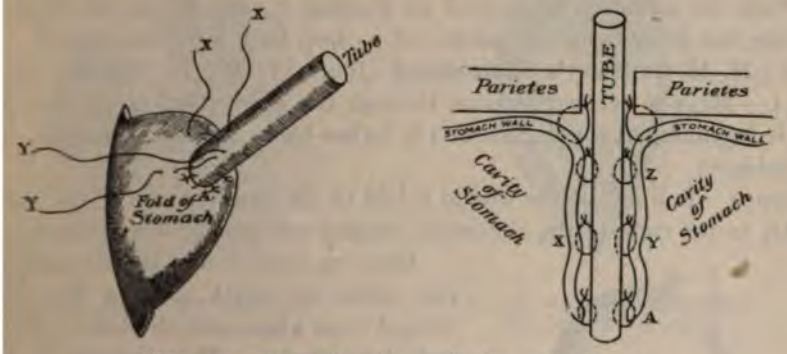
Frank's operation has the disadvantage that, the stomach being small, the peculiar formation of the fistula causes a deformity which seriously interferes with the carrying on of the normal functions.

(C) *Witzel's Operation.*—The object of this operation is to form an efficient fistula between the stomach and the skin and to make it oblique, so as to prevent leakage of gastric juices. In time the obliquity is lost, but yet leakage does not take place.

e Operation.—Open the abdomen through the rectus muscle by a two-
ertical incision to the left of the middle line. From the junction of the
of the stomach and its pyloric portion pull into the wound a fold of the
ch near the greater curvature, and here make a small incision, about the
e of a lead-pencil, through the serosa and musculosa. Pick up the mucosa
forceps and open the stomach cavity. Take a soft-rubber catheter, about
5 Fr.; close one end of the catheter or tube with a clamp and introduce
her end into the stomach. Cochem writes the author that he once found

FIGS. 475 AND 476.—Witzel's gastrostomy.

atheter here recommended became so easily clogged with food that the
tion was a failure until he substituted a catheter of the largest size. Fix
ube to the gastric wound with one or more catgut structures. Lay the
mal portion of the tube on the surface of the stomach and bury it by a row
mbert or continuous Lembert sutures, as shown in Figs. 475 and 476.
forms a canal in the stomach-wall. The canal should be 1¾ inches in
h or longer. Unite, with sutures, the outer opening of the canal to the



FIGS. 477 AND 478.—Stamm-Kader gastrostomy.

tal peritoneum. Bring the free portion of the tube out through the ab-
nal wound. Close the excess of abdominal wound. Over the portion of
ube external to the abdomen slide a short segment of a larger tube fitting
y to the main tube. This outer ring of tubing is pushed up to beside the
and through it is passed a safety-pin to prevent the drain from penetrating
r into the stomach. If the safety-pin was introduced into the main tube,
ch contents could leak out alongside of it and irritate.

Stamm-Kader Operation.—Expose and open the stomach as in the
l operation. Introduce a rubber tube and, with catgut, suture the edge

of the gastric wound to the tube. With fine chromicized catgut suture the gastric serosa, about ¼ inch distant from the wound, to the side of the tube all around it a short distance from the wound (Figs. 477 and 478). Insert a second row of these serous sutures. This causes an inversion or invagination of the stomach-wall, which serves as an efficient valve. With Lembert sutures unite the stomach around the tube to the parietal peritoneum. Bring the outer portion of the tube through the abdominal wound at a convenient point. Close the excess of abdominal wound. The Stamm-Kader operation is the only one applicable when the stomach is much diminished in size. It is an excellent, perhaps the best, method of operating.

An easier method of performing the operation is as follows:

Introduce a purse-string suture of catgut all around a small opening in the stomach-wall exactly as when a Murphy button is to be used. Through the opening pass the bulb of a Pezzer's self-retaining catheter into the stomach. Pull the catgut suture snugly round the shaft of the catheter and tie it. Introduce a purse-string suture of chromicized catgut in the stomach-wall round and about ½ inch distant from the catheter. As this suture is tightened push the catheter inwards and invert or invaginate the stomach-wall. Tie the suture but leave its ends long. Using the catheter as a handle pull the stomach up against the abdominal wall. With a needle fix the long ends of the purse-string suture to the peritoneum or the fascia of the abdominal wall. If desired introduce one or two sutures to unite the stomach, near the gastrostomy opening, to the peritoneum. (This is usually superfluous.) Close the abdominal wound. The catheter protrudes through the abdominal wall and aids in keeping the stomach in contact with it

When the catheter has served its purpose it may be cut off flush with the skin and its bulbous end permitted to drop back into the stomach.

(E) **H. H. Janeway's Gastrostomy** (Journ. A. M. A., July 12, 1913).—*Step* 1.—Make a vertical incision through the inner third of the left rectus muscle beginning at a point about 1½ inches below the costal margin. Open the abdomen.

Step 2.—Pull out of the wound a fold of the anterior wall of the stomach slightly to the right of the abdominal incision and anchor it with forceps.

FIG. 479.

Make an incision into the stomach about 1¾ inches in length along a line slightly oblique from above and the left to the right and downwards. This incision is nearly transverse to the long axis of the body. At each end of the incision make a cut about ½ inch long directed towards the greater curvature.

Step 3.—Make traction upwards at the point X (Fig. 479). Unite the edges X A C E of the gastric wound to the edges X B D F. The result is a tube about 2 inches in length and lined with gastric mucosa.

Step 4.—*Method A*.—Suture the base of the new canal to the margin of the rectus sheath and its tip to the skin.

B.—Invert the base of the canal for a short distance into the stomach
m a valve. Treat the rest of the tube as in Method A.
al if made as described has an oblique direction toward tshe left
fore in itself valvular. It is completely lined by mucosa and hence
catheterization is not necessary in order to keep it open.
atment.—It is better to administer nourishment per rectum for a
ter the operation, lest vomiting be set up. If the patient is urgently
nourishment, it may, however, be at once introduced by the catheter
omach. For weeks after operation the diet should be liquid; later
vell broken up or chewed by the patient may be permitted.
dication.—This operation is occasionally performed in cases of
tation. It is exceedingly simple and has for its object the diminu-
of the stomach.
—Open the abdomen and expose the stomach.
—Into the anterior surface of the stomach introduce several rows
ited Lembert sutures or some modification thereof. The result
ination of segments of the stomach-wall and consequent decrease
Fig. 480).
ration is not curative, in that the cause of the trouble is not touched,
is the rule.

G. 480.—Gastroplication.
(*Monod and Vanverts.*)

FIG. 481.—Duret's gastropexy.
(*Monod and Vanverts.*)

exy.—This operation has been performed when, on account of
, the patient has become a chronic invalid; suffers severely; is
ated, and none of these conditions is satisfactorily relieved by
non-operative methods of treatment. The object of the opera-
tore the stomach to, and retain it in, its normal position, and
dragging upon the gastro-hepatic omentum and pressure upon
and pelvic organs, as well as obstruction to the onward passage
he stomach offered by kinking of the duodenum. The condition
ally one of general visceral ptosis, hence the operation is commonly

ration.—Step 1.—Make an incision in the median line. Open

the peritoneum and expose the stomach in the lower part of the wound. Expose but do *not* open the peritoneum in the upper part of the wound.

Step 2.—Insert a continuous suture on the modified Lembert plan, so as to unite the stomach and upper undivided portion of peritoneum. When this suture is in place, make both ends of it penetrate the fibromuscular belly-wall and tie them there (Fig. 481).

Step 3.—Close the wound.

Rovsing's Operation.—Step 1.—Make a median incision from the ensiform cartilage to the umbilicus.

Step 2.—With the finger pull the stomach upwards to its normal level. Examine the pylorus for stenosis, etc.

Step 3.—Introduce fairly stout silk sutures as in Fig. 482. Do not tie them until the surfaces of the stomach and parietal peritoneum are scarified where they are to be apposed and the belly-wall is sutured.

Step 4.—Close the abdominal wound and place on it a pad of gauze or a plate of glass covered with sterile gauze the dimensions of which are a little greater than the stomach-surface which has to be fixed. Over the gauze pad or glass plate tie the sutures suspending the stomach. These sutures are left *in situ* for three or four weeks.

FIG. 482.—Rovsing's gastropexy.

The operation is not dangerous and has given some strikingly brilliant results. ("Archiv f. klin. Chir.," lx, 816.) Rovsing reports the following results: Complete cure, 63.2 per cent.; great improvement, 12.8 per cent.; improvement, 7 per cent.; slight improvement or no change, 12.8 per cent.; deaths, 4.6 per cent. None of the deaths could be fairly attributed to the operation (Trans. Surg. Section A. M. A., 1912).

Gastropexy (*Beyea's operation*) has been accomplished by means of shortening the supports of the stomach. The lesser omentum is thrown into transverse folds, which are rendered permanent by a few sutures. In introducing the sutures be careful not to include any blood-vessels in their bite. Sir Frederic Eve ("Brit. Med. Journ.," May 7, 1910) is a thorough advocate of a slight modification of Beyea's operation. The liver is well raised by an assistant and the lesser omentum fully exposed. The stomach is suspended by four or five interrupted silk sutures passed above through the upper part of the gastro-hepatic omentum and below through the lesser curvature *in front* of the vessels. The lesser omentum is much thicker close to the liver than it is lower down but if the whole membrane is equally thin then the sutures are passed through the liver substance itself, just anterior to the transverse fissure. Of seven cases operated on as above and observed for a sufficient time afterwards, six were cured.

Crouse ["Archives of Surg.," I, 559, 1920] reinforces the plication of the gastro-hepatic omentum by detaching the falsiform and round ligaments of the liver from their attachments to the umbilicus and abdominal wall, leaving the diaphragmatic and liver fixation points intact and then splitting the falciform ligament and sewing its raw surface along with the round ligament to the plicated gastrohepatic omentum.

ration for Ulceration of the Stomach.—It is tempting to advise opera-
cases of acute ulceration where there is a copious hemorrhage, but
r generally ensues under medical treatment and operation is proper
en the hemorrhage is not merely copious, but recurrent. Ulcers of the
i not producing stenosis ought to be buried by invagination with sutures,
r, they ought to be excised. Unless the invagination or the excision
se to stenosis, gastro-enterostomy ought not to be performed. Every
gastric ulcer with hemorrhage demands operation. For those who be-
at carcinoma of the stomach commonly arises on the basis of a chronic
is wise to excise or destroy all chronic or indurated ulcers whenever this
ically feasible. Balfour's cauterization is excellent for this purpose.
al ulcers require excision, cauterization or invagination to produce per-
stasis, plus gastro-enterostomy, otherwise the relief afforded by the
nterostomy permits partial healing of the ulcer, a return of the pyloric
i and a return of the symptoms. This rule does not apply when nature
elf produced the stasis by contraction of scar tissue and the ulcer has
Excision of duodenal ulcers is rarely necessary as a prophylactic
malignancy but the cautery excision is of great value in preventing
ent hemorrhage.

ald Balfour (Sur., Gyn., Obst., xix, 528) has had very good results from
of the cautery. If the ulcer is on the lesser curvature he carefully
free the adjacent lesser omentum and then burns the ulcer completely
Paquelin cautery kept at a dull heat. This of course perforates the
. The wound is closed by a few through-and-through chromicized cat-
hes and these are buried by interrupted sutures of chromicized catgut.
rted lesser omentum is replaced and fixed to the site of ulceration. In
cases the peritoneum and muscularis may be reflected as a flap from
ulcer; the ulcer slowly burned; the perforation closed with catgut
nd the flap replaced. (Mayo, Journ. A. M. A., Sept. 25, 1915.)

ahan writes (Brit. Med. Jour., July 12, 1919).—"Nowadays I perform,
only two operations for cases of chronic gastric ulcer. If the ulcer is
he œsophagus, and is of average or small size, I perform partial
y. If the ulcer is very large, burrowing deeply into the liver or
as, and near the cardiac end of the stomach I perform gastro-enter-
Y, and into the proximal limb of the jejunum, below the duodeno-
ure, I introduce a tube, performing jejunostomy. Through this
atient is exclusively fed, for few or many months, until an X-ray
n suggests that the ulcer is healed."

st always bear in mind that in pure neurasthenia many of the
f gastric ulcer may be present, the stomach may be dilated, etc.,
ient may be in such a frame of mind as to tempt the surgeon to
tro-enterostomy. If the abdomen is opened and no scar of ulcer
d there is no enlargement of the gastric lymph nodes indicating
perform gastro-enterostomy, as the latter state of such a patient
ie to be worse than the first. The most experienced surgeons are
keptical as to the existence of the so-called "mucous ulcers" which
g but cannot be *seen* either on the operating or postmortem table.

Whenever there is acute perforation of the gastric wall from ulceration, operation is imperative. Excision of the ulcer is unnecessary. All that is necessary is to close the ulcer with a single stitch of catgut and to infold the ulcer and a portion of healthy stomach with two rows of continuous Lembert sutures (Moynihan) or to use Balfour's operation. If there has been much soiling, flush the cavity; "if the operation is done within ten or twelve hours, a gentle wiping of the surrounding area with wet swabs will suffice. Drainage, as a rule, is not necessary except in the late cases. When adopted it should be free, a split tube and a gauze wick being placed in the original incision and in a second suprapubic opening." Do not be content with finding and closing one perforation: look for more.

When operating for perforating ulcer, if the patient is in very poor condition, it is often wise to follow W. G. Richardson's advice (Northumberland and Durham Med. J., Nov. 12, 1903) and pass a rubber tube through the perforation into the stomach. By stitching the stomach surrounding the tube to the parietes a fistula is established through which the stomach may be washed and food administered. After a few days the tube may be removed and usually the opening closes spontaneously.

In the preceding remarks no account has been taken of the presence of adhesions, or of scars and stenoses resulting from ulceration. Adhesions are Nature's means of protecting the peritoneal cavity from general infection, but while immediately life-saving, they are very liable to occasion much gastric disturbance, and certainly make operative interference much more difficult. The mere breaking-down of gastric adhesions (gastrolysis) often suffices to cure apparently inveterate cases of dyspepsia. Mayo Robson ("Transactions Am. Surg. Association," xix) has carried out this treatment fifty-six times with complete success. Before closing any perforation or before uniting bowel to stomach, if adhesions exist, they must be so broken down or divided that the parts to be united tend to lie together, and the sutures when inserted keep the parts together *without any tension. Tension on sutures is fatal.* The technical difficulties occasioned by adhesions may dominate the choice of operation for the relief of ulcer or its sequelæ. More than 90 per cent. of gastric ulcers are situated along the lesser curvature, often constituting the so-called saddle ulcer where the disease extends on to both the anterior and posterior walls of the stomach. Ulcers not along the lesser curvature are more frequent on the posterior than the anterior wall of the stomach. Less than 6 per cent. of the ulcers seen are multiple (Mayo). It is very commonly accepted that chronic gastric ulcers may and do act as the starting-point of malignant disease. Influenced by the above consideration, Rodman has suggested the advisability of excising the pylorus and that portion of the stomach most commonly the seat of ulceration. The lines of incision advised by this surgeon are shown in Fig. 483. Operations for the excision of gastric ulcer are described in the sections devoted to partial gastrectomy and to pylorectomy.

FIG. 483.

Gastro-enterostomy, or anastomosis between the stomach and intestine is indicated in cases of pyloric obstruction, and of ulceration. According to

portion of intestine selected for anastomosis, the name "gastro-duodenos-
y" or "gastro-jejunostomy" may be used.

According to whether the gut is united to the anterior or to the posterior
l of the stomach, the operation is designated "anterior" or "posterior
tro-enterostomy."

Wölfler's Operation.—Anterior Gastro-enterostomy.—The preparation of the
ient is the same as in exploratory gastrotomy.

Step 1.—Open the abdomen by an incision in or near the middle line, be-
en the umbilicus and the ensiform cartilage. The cut is about four inches
5.

FIG. 484.—Anterior gastro-enterostomy. (*Mayo.*)

Step 2.—Expose the small intestine by pulling the omentum upwards and
the left. Find the jejunum by the method described on page 366. Empty
loop of gut and apply clamps to keep it empty.

Step 3.—On the lowest possible point of the anterior wall of the stomach
ct a spot for the stomach opening (Fig. 484). Pull this portion of stomach
l the loop of jejunum out of the belly and protect the cavity with gauze pads.
ke an anastomosis between the stomach and the jejunum, using either
ures or the Murphy button. The method of making the anastomosis is
ntical with that employed in posterior gastro-enterostomy, page 368.

Step 4.—Cleanse the field of operation. Put aside all instruments which

have touched the mucosa. Inspect the line of union, and if necessary reinforce it with a few Lembert sutures. If the point of union causes the intestine to kink sharply, this may be remedied by a few stitches uniting to the stomach a little more of the afferent or efferent portions of gut or of both.

Step 5.—Close the abdominal wound. The after-treatment is the same as for exploratory gastrotomy. Anterior gastro-enterostomy is practically obsolete. Occasionally it may be of use in pyloric obstruction when the patient is so weak that the simplest possible method must be chosen and under such circumstances possibly a jejunostomy might be preferable.

Posterior Gastro-enterostomy. *Step* 1.—Expose the stomach through an incision ¾ inch to the right of the median line. Examine the whole anterior surface of the stomach and duodenum. No matter what condition is apparent at the first glance, there may be something else present, *e.g.*, a trifid stomach, which it is necessary to recognize. Remember that enlarged lymph nodes may give information as to the site of an ulcer.

FIG. 485.—Exposure of beginning of jejunum.

Step 2.—Lift the transverse colon out of the abdomen and by pulling upwards and to the right, bring so much of the mesocolon with it that the jejunum becomes visible (Fig. 485). The jejunum from its point of origin at the transverse mesocolon passes downwards, to the left and backwards, *i.e.*, it goes into the left kidney pouch below the splenic flexure of the colon. The duodeno-jejunal junction (the origin of the jejunum) is well fixed or immobile, lies about 1½ to 2 inches above the umbilicus and its level is only about 2 inches lower than that of the pylorus. To avoid kinking, any anastomosis between the stomach and jejunum should be made along the natural line of relationship between these two viscera, *i.e.*, along a line on the posterior gastric wall running from above downwards and towards the left. The origin of the jejunum being a fixed point, if the anastomosis is made at too high a level the jejunum will pull the stomach upwards and trouble may result. If the anastomosis is too low there will be a loop of jejunum above it and if, as has often happened, this loop becomes filled with bile, etc., the weight of its contents can pull it down and cause angulation at the anastomosis. This is the principal cause of the 'vicious circle' which was the chief danger in the early days of gastro-enterostomy.

Pick up a proper loop of jejunum, usually about three inches from the duodeno-jejunal junction. Note the fold of peritoneum passing from the jejunal origin to the transverse meso-colon; near where this fold joins the mesocolon is the best place to tear a hole in the mesocolon and expose the posterior surface of the stomach (Fig. 486). Sometimes this fold of peritoneum (ligament of Treitz) extends so far down the jejunum that an anastomosis between the stomach and the jejunum distal to the fold leaves sufficient gut above the anastomosis to form a dangerous loop. When such is the case divide the fold of

FIG. 486.—Colon and transverse mesocolon pulled upwards exposing jejunum.

Exposure stomach through rent in mesocolon. Limited separation of gastro-colic omentum and gastro-epiploic vessels from lowest point of greater curvature of stomach permits exposure of small portion of anterior wall stomach. Fold of stomach in clamp consists of a small portion of the anterior and large portion of the posterior wall.

peritoneum as the avoidance of any loop of gut above the anastomosis is of prime importance. Division of the fold is not always innocuous. J. H. Nicoll (Brit. Med. Journ., Oct. 21, 1916) found in one case, that the resultant raw surface on the intestine became adherent to the under surface of the transverse meso-colon causing occlusion of the loop of gut leading to the neostoma. There was reflux of duodenal contents through the pylorus into the stomach with inveterate vomiting. If the raw surface on the jejunum is utilized in the gastro-enterostomy, *i.e.*, if the opening into the gut is made in this area then the accident reported by Nicoll could hardly arise.

Step 3.—Tear a hole through a non-vascular area of mesocolon [illegible] portion of the posterior wall of the stomach through this hole. By [illegible] the gastro-colic omentum, and with it the gastro-epiploic artery [illegible] greater curvature of the stomach for a short distance it is easy to pull [illegible] of the anterior as well as of the posterior wall of the stomach through [illegible] in the mesocolon (Fig. 486). It is important to do this in order to [illegible] very lowest point of the stomach. Apply a gastro-enterostomy clamp [illegible] fold of stomach, including about one inch of the anterior wall. The [illegible] of the clamp and of the contained fold must be from right to left, [illegible] above downwards (Fig. 486).

Step 4.—Apply a similar gastro-enterostomy clamp to the jejunum [illegible] its long axis. The highest point of the gut grasped in the clamp must be [illegible] to 3½ inches from the duodeno-jejunal junction (Fig. 487).

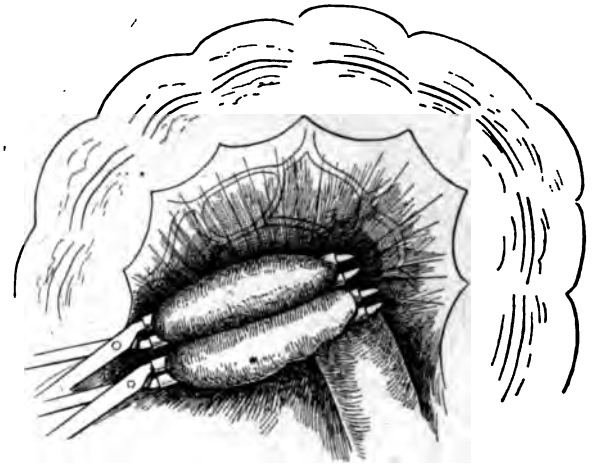


FIG. 487.—Posterior gastro-enterostomy.

Step 5.—Lay the two clamps side by side. Place a narrow gauze pad immediately behind the clamps, between the stomach and the jejunum. With other pads placed beneath the clamps and around the segregated portions of stomach and jejunum thoroughly shut off from contamination the abdominal cavity and the abdominal wound.

Sinclair White and some others have given up the use of clamps because of fatal hemorrhage having taken place from the suture line after their removal. If the following method is used there is little if any danger of bleeding, certainly the danger from this source is less than the danger to be apprehended from soiling of the field of operation and from loss of blood during the operation in weak patients when the clamps are not used. When hemorrhage takes place it is from the posterior suture line of the gastro-jejunostomy.

Unite the stomach to the jejunum for a distance of about 2½ inches by a row of mattress sutures exactly as in intestinal lateral anastomosis (posterior serous suture). Make an incision parallel to and shorter than the posterior serous suture, through all the coats of the stomach except the mucosa. The

outs up into the wound. Make a corresponding incision in the roduce a button-hole or locking continuous suture of chro-nalinized catgut, including in each stitch (a) a bite of the unopened a, (b) the other coats of the stomach, (c) the serous and muscular ejunum, (d) a bite of the unopened jejunal mucosa. This line s the posterior edges of the stomach wound to the corresponding jejunum (Fig. 488). Incise the mucosa of the stomach and

astro-jejunostomy made with three lines of sutures on posterior line because iorrhage into the gastro-intestinal tract after clamps are removed. Drawing ton-hole (second line of sutures) suture applied posteriorly without opening ne. (*Mayo.*)

ith the same needle and catgut suture used in the preceding line by a whip stitch the mucous coats of the stomach and jejunum Vith the same suture unite the anterior edges of the stomach wounds by means of a Connel stitch (through all the coats of the a through-and-through buttonhole (or locking stitch) exactly as tomosis. Remove the intestinal clamps. Complete the serous teral anastomosis. Discard all instruments used in making the hey are soiled. Cleanse the operative field. Remove the gauze ing hold of both ends of the narrow gauze pad or strip placed be-of anastomosis and manipulating it properly it is easy to bring whole posterior surface of the anastomosis for inspection. *If*

necessary introduce one or more Lembert or Gould sutures to assure safe union. The gastro-enterostomy is complete.

Step 6.—Unless the opening in the gastro-colic omentum is rendered secure hernia of the small intestine or omentum through it into the lesser peritoneal cavity can take place and cause disaster.

With three or four sutures unite the lower peritoneal surface of the mesocolon, a quarter of an inch away from the rent, to the suture line and tuck in the torn edges of the rent so as to avoid adhesions. If the mesocolon is *fat*

FIG. 489.—Gastro-jejunostomy made with three sutures on posterior line because of occasional hemorrhage into the gastro-intestinal tract after clamps are removed. Drawing shows mucous membrane opened. Running suture of catgut to bring mucous coats of stomach and jejunum together. (*Mayo.*)

attach the torn margins of the opening to the stomach (instead of to the suture line) so as to avoid the formation of a collar-like band at the anastomosis (Mayo).

In order to give nourishment early after gastro-enterostomy and to avoid irritating the stomach with food, A Hammestahr (Cent. für Chir., Jan. 6, 1903) uses Rutkowsky's method of combining a gastro-enterostomy with a gastrostomy. A catheter is introduced through the gastric fistula into the jejunum and is kept in place until the stomach is in condition to take care of food. Feeding is carried on through the catheter. On removal of the catheter the

fistula quickly closes. The method seems entirely unnecessary and objectionable.

Maury's Method.—Maury's operation is essentially a modification of McGraw's, but is accomplished with materials always at hand (strong cord instead of elastic ligatures).

Steps 1, 2, 3 are the same as in the preceding operation, except that no clamps are used.

Step 4.—Lay the chosen segment of jejunum against the lower portion of the stomach. Insert a row of Lembert sutures, 90 degrees distant from the mesentery, and so unite the intestine to the stomach. Leave the ends of this the posterior line of Lembert sutures, long.

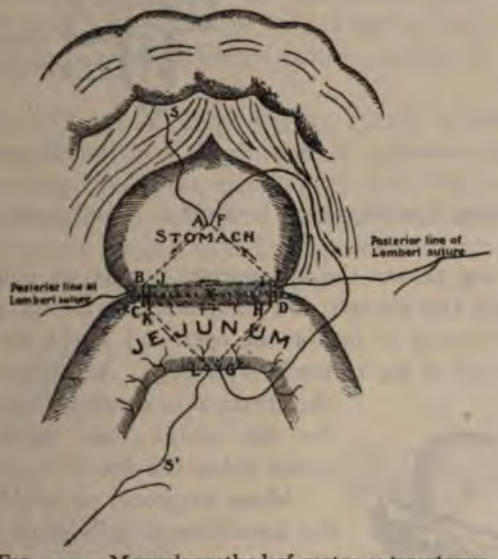


FIG. 490.—Maury's method of gastro-enterostomy.

Step 5.—Thread a straight, round needle (darning-needle), 3 inches long, with very strong twine. Introduce the needle into the stomach at the point A (Fig. 490). Be sure the mucosa is penetrated. The point A should be near the vessels of the greater curvature, and the distance between A and X (the mid-point of the line of Lembert sutures) should be less than the diameter of the gut. Bring the needle out from the stomach at the point B, ¼ inch from the beginning of the Lembert suture. Make the needle traverse the intestine from C to D and the stomach from E to F. The points D and E must be ¼ inch from the ends of the Lembert suture.

Make the same needle and thread traverse the gut from G to H, the stomach from I to J, and lastly the gut from K to L.

This apparently complicated but really simple series of stitches forms two equal triangles the apices of which (A F, L G) are equidistant from the middle of the base (X).

Step 6.—Pull firmly on the ends of the twine (S, S') and tie very tightly. This is of great importance, as necrosis of the included tissues is essential.

Step 7.—Continue the line of Lembert sutures already in place completely around the site of the twine. The tying of the twine will have thrown the surface of the gut into a number of radiating folds, therefore to obliterate these while completing the Lembert sutures insert the stitches as much as possible at the bottom of these sulci.

FIG. 491.

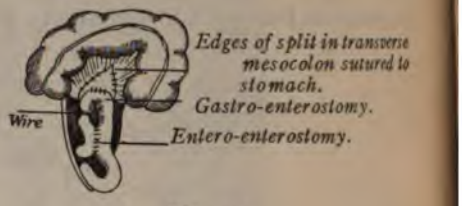


FIG. 492.

Roux's Operation; Operation en Y.—*Steps* 1, 2, and 3, as in posterior gastro-enterostomy.

Step 4.—Having chosen the appropriate portion of jejunum, empty it of its contents, apply two clamps, and completely divide the gut between them. Anastomose with suture or button the open end of the lower segment of gut to the posterior wall of the stomach (Fig. 493). Anastomose the open end of the proximal or duodenal segment of the gut to the side of the lower segment of gut, a few inches below the site of the gastro-enterostomy.

FIG. 493.—Roux's gastro-enterostomy. (*Monod and Vanverts.*)

Many surgeons, to avoid the possibility of the formation of a "vicious circle" (page 375), complete the gastro-enterostomy by forming an anastomosis between the afferent and efferent loops of jejunum at a point 6 inches lower down the gut (Fig. 491). Fowler, to make assurance doubly sure, encircled the afferent loop, between the two points of anastomosis, with a silver wire thread to obliterate its lumen; the same object may be attained by a purse-string suture of silk around the gut at the same place, Fig. 492.

Pyloric Exclusion.—The above methods endeavoring to obliterate the gut lumen have proven unreliable, at least in the case of the pylorus, as the sutures or ligatures become extruded into the gut which soon assumes its former size. Lambotte finds that if the ligature is tied tightly enough to obstruct but not tightly enough to strangulate or cause pressure, then the desired occlusion is attained and maintained. Brewer uses strips of aluminum instead of threads.

For the same purpose and also to prevent the passage of food into the duodenum after gastro-enterostomy for duodenal ulcer various methods of

oric exclusion have been practised. Operative closure of the stomach or denum above the ulcer is not indicated when there is sufficient stenosis due he ulceration.

Bier writes: "pyloric occlusion ought never to be omitted in cases of gastro-nostomy when well-marked stenosis is absent and when the operation has n performed for very painful or bleeding ulcers of the pylorus or particularly he duodenum."

1. *Doyen and v. Eiselsberg's Method.*—Choose a place to the oral side of the r and in healthy tissue. Make an opening, close to the lesser curvature, ough the lesser omentum and a corresponding opening close to the greater vature, through the gastro-colic omentum. Apply two clamps to the stom-. Place a strip of gauze behind the clamped portion of the stomach. ide the stomach between the clamps with a thermo-cautery. Close each np by a row of through-and-through sutures buried by a row of serous ures.

2. *Bartlett's Method* (Journ. A. M. A., Aug. 15, 1914).—Choose a place on the l side of the ulcer (whether of the duodenum, pylorus or pyloric antrum). ke an opening through the great omentum close to the greater curvature. ply two crushing clamps to two-thirds of the diameter of the stomach and cut ween them. Close the wound with through-and-through sutures. Bury s line of sutures by serous sutures (Fig. 494).

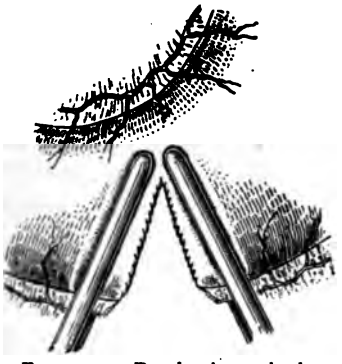


FIG. 494.—Bartlett's method.

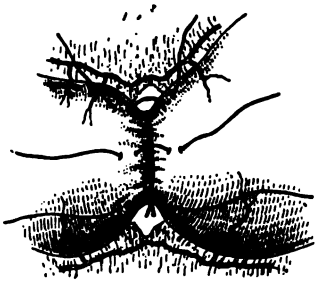


FIG. 495.—Bier's method.

3. *Bier's Method.*—Well to the oral side of the ulcer and on healthy tissue ply a crushing clamp, *e.g.*, Payr's, to the stomach. Remove the clamp and lace it by a strong ligature. Bury the ligature with a row of serous sutures g. 495).

4. *Author's Method.*—Ligate and cut away a sufficient tag of great omentum. ply this tag like a ligature tightly around the pylorus. Bury the implant a row of serous sutures. A strip of fascia may be used in the same fashion ilms).

5. *C. H. Mayo's Method.*—Introduce a closed hemostat through the great ntum close to the greater curvature, pass it upwards behind the stomach make its point seize the lesser omentum some distance above the lesser ature. Pull the lesser omentum behind the stomach out through the per-

forated great omentum and then upwards in front of the stomach to be sutured to the rest of the lesser omentum.

6. *Brewer* (Surg., Gyn., Obst., Feb. 1914).—Pass a band of aluminum about 5 cm. long by 1 cm. wide around the pylorus and compress it sufficiently to obliterate the lumen without interfering with nutrition.

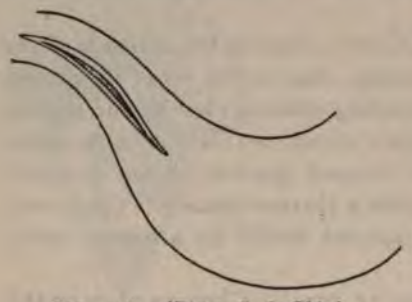


FIG. 496.—(*Porta, J. de Chir.*)

FIG. 497.—(*Porta, J. de Chir.*)

FIG. 498.—(*Porta, J. de Chir.*)

FIG. 499.—(*Porta, J. de Chir.*)

FIG. 500.—(*Porta, J. de Chir.*)

FIG. 501.—(*Porta, J. de Chir.*)

7. *Biondi's Method* (Figs. 496 to 501).—In the middle of the anterior surface of the antrum pylori make an incision about 6–10 cm. long in the long axis of the stomach and duodenum. Most of this incision should be on the gastric side of the pylorus. Cut through the peritoneum and the muscular and submucous tunics but leave the mucosa intact. Shell a segment of the mucosa

ube out of its submucous bed and doubly ligate and divide this tube
h end. Close the wound in the serous and muscular tunics. Of these
ds, section of the pylorus (Doyen, v. Eiselsberg, Bartlett) is the most
ious and least safe.

ondi's operation seems good. Probably the methods devised by the
r and Bier are the simplest and *least* efficacious.

stead of using these methods of pyloric occlusion, some surgeons having
emented the gastro-enterostomy by making a lateral anastomosis be-
the afferent and efferent loops of jejunum completely divide the afferent
etween the two points of anastomosis and close the open ends of the gut
rse-string sutures (Fig. 491). This method has all the advantages of
s operation, but does not interfere to the same extent with the mesentery.
certain that in the hands of most surgeons, the dangers of the vicious
are less than those incident to the complicated methods devised for its
ance.

clusion of the duodenum must never be practised if the McGraw elastic
re or Murphy's triangular string method have been employed in making the
-enterostomy. By these methods it takes about seventy-two hours to
lish gastric drainage. Maury's experiments ("Surg., Gyn. and Obstet-
May, 1906) clearly show that if, in dogs, the gut is divided and both ends
at any point nearer to the pylorus than 14 inches (35 cm.) and the distal
nt is united to the stomach by the ligature method, the dog will promptly
ith symptoms of tetany. The death in these cases seems to be from some
of auto-intoxication due to the want of gastric drainage, because when a
is established between the stomach and the distal portion of gut at the
of the operation, no such catastrophe arises.

e Vicious Circle.—When the afferent portion of gut is so placed that
ch contents pass into it instead of into the efferent loop, grave conse-
es are liable to ensue, and to the condition the name "vicious circle" has
given. The accident seems to be very rare after posterior gastro-enter-
y. Roux's operation, "en Y," almost precludes its possibility, and the
s methods of adding an enterostomy to the gastro-enterostomy give safety
ard to the vicious circle, but of course add distinctly to the gravity of
perative procedure. No symptoms of the vicious circle seem to have
ed the performance of the *no-loop* operation.

ptic, Gastro-jejunal or Jejunal Ulcer.—Braun and Mikulicz have shown
the duodenum and upper segments of the jejunum are more resistant to
orrosive action of the gastric juices than are the lower segments of gut.
sterior gastro-enterostomy the portion of gut opened is 9 inches below
uodeno-jejunal fold, while in the anterior operation it is 16 to 20 inches
that point. Several cases of fatal peptic ulcer have been noted after the
ior operation—hence this constitutes an argument in favor of the posterior
specially of the no-loop method. The ulcers occur at the point of anasto-
s or within 4 inches of it.

Mayo finds that the employment of continuous non-absorbable sutures (even
e serous coats) in gastro-enterostomy occasionally causes ulceration at the
f anastomosis.

If jejunal ulcer is diagnosed some time after the operation of gastro-enterostomy and general treatment has proved useless the abdomen must be opened again and the anastomosis and neighboring jejunum examined.

Mayo-Robson ("Brit. Med. Journ.," Jan. 6, 1912) advises as follows:

1. There is ulceration at the anastomosis or in the jejunum. The original pyloric or duodenal ulcer has healed (without stenosis). Detach the jejunum from the stomach. Excise the ulcer. Close the openings in the stomach and jejunum. If the gastro-jejunal ulcer is extensive excise that segment of gut. Restore the continuity of the gut by end-to-end anastomosis. Close the opening in the stomach.

2. The pyloric or duodenal ulcer in healing has caused stenosis. Either choose a new site for posterior anastomosis or perform Roux's gastro-enterostomy, after excising the ulcer or the ulcerated segment of jejunum.

3. The anastomotic opening is healthy; the jejunum alone is affected. Excise the ulcer, repair the bowel, do not interfere with the anastomosis.

4. If the patient is profoundly ill and unable to bear a prolonged operation perform jejunostomy, so that he may be fed and the ulcer, whether in the jejunum, stomach or duodenum, can be given complete rest until healing is effected.

Choice of Method by Which to Effect the Anastomosis.—Unless under very exceptional circumstances the anastomosis by suture is the method of choice. Where haste is the prime consideration Murphy's button has its place of usefulness as a time saver.

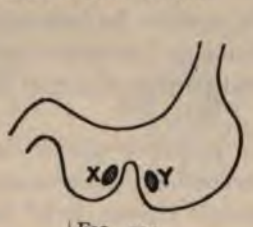


FIG. 502.

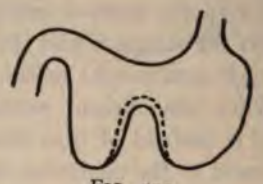


FIG. 503.

FIG. 504.

FIG. 505.

FIG. 506

FIG. 507.

FIGS. 502 TO 507.—Hour-glass stomach. (*Moynihan.*)

Operation for "Hour-glass" Stomach.—The figures (502 to 507*) sufficiently explain the older methods of operating on hour-glass contraction of the stomach. In Fig. 502 an anastomosis is made between the two gastric pouches at the points X and Y. In Fig. 505 the cardiac pouch, being large and dependent, is united to the jejunum. In Figs. 503 and 504 and incision is made through the lowest part of the constriction and when the edges of the cardiac side are

* Figs. 502 to 507 are taken from Moynihan's work, but Figs. 503 and 504 have been modified.

united to those of the pyloric side, the normal shape of the stomach is more or less restored. The principle of this operation is identical with that of Mikulicz's pyloroplasty.

Note that pyloric stenosis may accompany hour-glass stomach. When this is so, the condition must be corrected or a gastro-enterostomy established.

Hour-glass stomach is the result of ulceration and as carcinoma is often grafted on to an old ulcer it is wise to excise the affected portion of the stomach (see Partial Gastrectomy, Segmental Excision of Ulcer, etc). The operations of gastro-gastrostomy (Fig. 502) and double gastro-enterostomy (Fig. 506) have not given great satisfaction.

OPERATION UPON THE PYLORUS.

Congenital Pyloric Obstruction.—Cases of congenital pyloric obstruction which do not promptly yield to medical treatment must be subjected to operation.

Operation may either avoid or remove the obstruction. Gastro-enterostomy gives excellent ultimate results, but in this class of case it's death rate is high. (Scudder, Annals of Surg., lix, 257, 1914, 23.5 per cent. Downes, Surg. Gyn. and Obstetrics," xxii 251, 1916, 35 per cent.) The Fredet-Rammstedt operation and it's modification by A. Strauss seeks to remove the obstruction. Downes reported (Jour. A. M. A., lxxv, 228) 165 operations by the Fredet-Rammstedt method with 30 deaths (17 per cent.) while Strauss (Surg. Clinics of Chicago, ix, 93, 1920) reported 103 operations by his own method with but 3 deaths.

Fredet-Rammstedt Operation.—From beside the umbilicus make a 1½ inch incision upwards through the right rectus muscle. Deliver the pylorus and rotate its superior surface forwards. Incise the tumor longitudinally, from end to to end, through the bloodless area above the limits of the pyloric vein. Carry the incision down to, but not into, the submucosa which shows a white glistening membrane. With blunt scissors separate the musculosa from the submucosa for about ¼ inch on each side of the wound. Gas now escapes from the stomach through the pylorus to the duodenum and the distended stomach collapses. (If there is any doubt as to the patency of the pylorus open the stomach and pass dilating forceps through the constriction. Close the wound in the stomach.)

Replace the pylorus in the abdomen. Do *not* suture the wound in the pylorus. Close the abdomen.

Strauss' Operation.—Open the abdomen and deliver the tumor as in the Fredet-Rammstedt operation. With a knife make an incision over the most bloodless part of the tumor throughout its whole extent. Only *cut* the superficial layers of the musculosa. With the handle of the scalpel split the rest of the musculosa at the stomach end of the tumor, until the submucosa is reached. From this point continue the splitting of the muscle down to the duodenal end of the tumor. Should the mucosa be accidentally opened close it's wound by a few catgut stitches. Seize the edges of the split tumor with fingers and thumb and spread them apart like opening a book (Fig. 508). Be sure that every muscle fiber of the tumor is separated down to the duodenum. With a blunt instrument separate the mucosa from the musculosa until the former is entirely free. Make a flap of musculosa with its hinge at

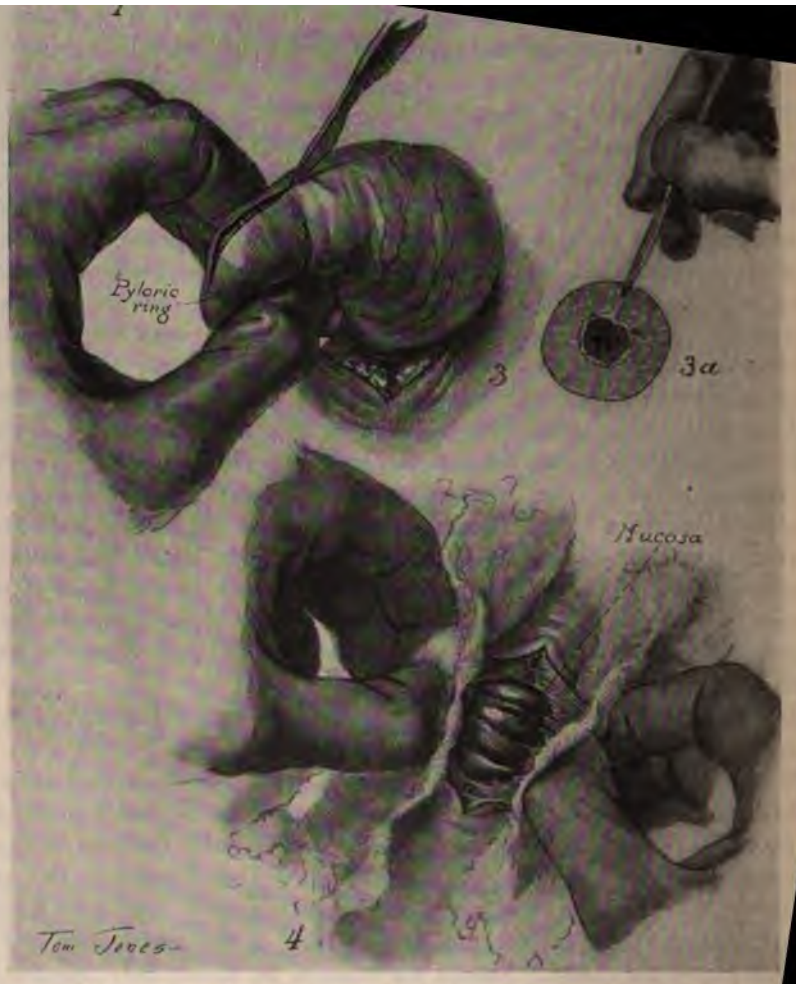


FIG. 508.—Congenital pyloric stenosis. The abdomen is opened by a right rectus i (1) and the pyloric tumor brought out by means of a blunt hook (2). The superficial l peritoneum and muscle are incised with the blade of the knife (3 and 3*a*), but the furt section to the mucosa is made with the handle. The flaps of muscle are turned out fingers, exposing the mucosa (4) and the mucosa shelled out. (*Alfred A. Strauss*, in Clinics of Chicago, February, 1920.)

. 509.—Congenital pyloric stenosis. A flap of muscle is made by splitting one of the of the incision (5) and is stitched over the bulging mucosa (6); this in turn, is covered entum (7). A cross-section of the condition as pictured in 6 is shown in 8. (*Alfred* ams, in Surgical Clinics of Chicago, February, 1920.)

the edge of the longitudinal split through the tumor. Sew this flap over the bulging muscosa. Pull a piece of omentum over the site of the operation and fix it there with a few stitches (Fig. 509). Close the abdomen. The operation is not difficult and has been very successful. The author has used both gastro-enterostomy and Strauss' operation with satisfaction.

Pylorodiosis.—When pyloric stenosis is due to spasm or hypertrophy of the sphincter this operation may be indicated, but as it has proved to be by no means safe and recurrence of the trouble is frequent after its performance, and as other methods give more certain results, the operation is not much in favor.

Hahn's Method of Performing Pylorodiosis.—Expose the stomach by an incision to the right of the middle line. With the finger invaginate a portion of the anterior wall of the stomach and push it, along with the finger, through the pylorus. When the pylorus is sufficiently dilated, close the abdominal wound.

Loreta's Method.—Expose the pylorus. Incise the stomach near the pylorus. Through the stomach-wound pass the forefinger of each hand into the pylorus and forcibly dilate it. Instead of the fingers bougies may be used.

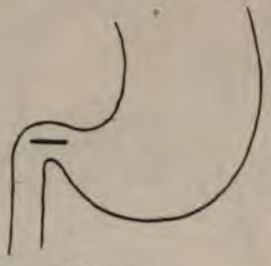
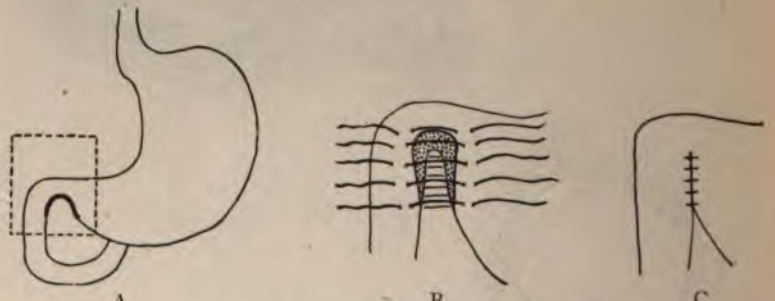


FIG. 510.

FIG. 511.

Pyloroplasty. Wrong method.



A B C

FIG. 512.—Pyloroplasty. Correct method.

Pyloroplasty (Heineke-Mikulicz operation) is indicated in cases of spasmodic or cicatricial pyloric stenosis.

Step 1.—Expose the stomach near the pylorus by a vertical incision. Explore the *whole* stomach lest coexistent disease be overlooked. Separate adhesions which may exist around the pylorus. If possible, pull the pylorus out of the abdomen. Protect the peritoneal cavity with gauze pads. Clamp the stomach and duodenum with appropriate instruments (*e.g.*, Doyen's clamps).

Step 2.—Make a small opening into the stomach near the stenosis. Pass a er or an instrument through the pylorus as a guide. If is generally advised nake a longitudinal incision through the *anterior* wall of the pylorus, com- ely dividing the stricture, and then to convert the longitudinal into a trans- se wound and close it by sutures (Figs. 510, 511). But, as Mikulicz re- rked "that is not the way we do it." According to him, the longitudinal sion is made on the under surface of the stenosed pylorus (Fig. 512, A, B,

Having made this inferior incision, unite the posterior edges of the wound t by a continuous or interrupted row of Lembert sutures, and then by a row sutures embracing the whole thickness of the walls. Continue the latter row as to close the anterior edges of the wound, and complete the union by in- ting an anterior row of Lembert sutures. It is very evident that this method sesses all the good qualities of that usually described, and has the great vantage, in addition, that it lowers the level of the exit of the stomach.

Finney's Operation.—Finney's operation is a most valuable contribution to rgery and in many cases it is a desirable substitute for gastro-enterostomy. hen as a result of ulceration there is a spastic condition of the pylorus the rest ured through gastro-enterostomy gives a very brilliant immediate result, t as spasm abates food once more resumes its normal route through the py- us, the artificial opening is liable to contract, and recurrence of the trouble requent. In such cases Finney's method is of great service. The presence many adhesions is stated to be a contra-indication to the operation but it s exactly in such a case, where adhesions impeded gastro-enterostomy, it Finney noticed how closely and conveniently the duodenum and stomach together and at once proceeded to unite them. Many variations in tech- ue have been devised but the principles of all are the same and the author l take the liberty of describing the operation as he has done it himself.* amps may or may not be used.

The Operation.—The abdomen having been opened and the pylorus with e adjacent portions of the stomach and duodenum, if possible, pulled out of e abdominal wound, protect the peritoneum thoroughly with gauze packs.

Step 1.—Unite the adjacent surfaces of stomach and duodenum by a con- uous Lembert suture (A, B. Fig. 514). (Posterior line of serous suture.)

Step 2.—Make the ∩-shaped incision XYZ (Figs. 513 and 514), opening th the stomach and duodenum and dividing the pylorus.

Step 3.—Unite the two posterior edges of the ∩ incision by means of Connell tures or by a through-and-through whipping-stitch (Figs. 514 and 515). this stage scar tissue or active ulcers present in the anterior wall of the omach or duodenum may be excised through the incision. Ulcers in the sterior wall may have their overhanging mucous edges trimmed and their use fibrous base incised, care being taken to avoid perforation and to stop bleeding by ligature or suture. With the same suture unite the two anterior ges of the ∩ incision (Fig. 515).

Step 4.—Continue the Lembert suture introduced in Step 1, around the terior surface of the anastomosis (anterior line of serous suture) and bury m sight the stitches introduced in Step 3.

* This account of the operation was submitted to Finney and met his approval.

Fig. 516 shows in section the result of the operation. An examination of 78 cases seen from one to twelve years after operation showed an average of 93.8 per cent. satisfactory results. (Finney, Surg., Gyn., Obst., March, 1914.)

If it is difficult to lay the duodenum along side of the stomach without tension it is easy to make a vertical incision through the parietal peritoneum two finger-breadths to the right of and parallel to the descending portion of

FIG. 513.

FIG. 514.

FIGS. 513 AND 514.—Finney's operation.

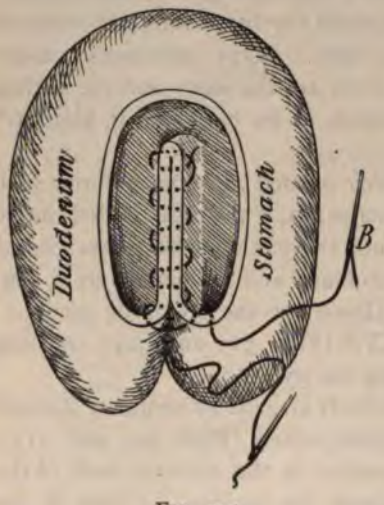


FIG. 515.

FIG. 516.

FIGS. 515 AND 516.—Finney's operation.

the duodenum (Kocher). The fingers introduced through the wound in the peritoneum easily separate the duodenum (and with it, if necessary, the head of the pancreas) from the vertebral column, vena cava and aorta and so mobilize the gut that Finney's operation becomes easy.

How extensive ought one to make the new opening between the stomach and duodenum? Finney makes a very extensive opening and finds it satis-

y. The Mayos think the lower end of the new opening ought not to as low as the ampulla of Vater.

cision of Gastric Ulcers.—Codman points out that ulcers of the stomach actically always confined to the lesser curvature; when they are ap- ly posterior, it is because adhesions to the pancreas, etc., so twist the ch as to make the lesser curvature appear to be the posterior wall of iscus. Excision of the ulcer-bearing area, when done in the classical n, sacrifices unnecessarily the greater curvature, renders difficult the e of the gastric wound near the œsophagus and does not permit of igh exploration of the interior of the stomach.

dman operates as follows (personal communication):

p 1.—Open the abdomen and explore.

p 2.—Divide the gastro-hepatic omentum. Divide the gastro-colic um leaving intact the left gastro-epiploic vessels. Doubly clamp and the duodenum near the pylorus. Treat the duodenal stump *secundum* and let it drop back into the abdomen.

p 3.—At this point the jejunum should be sought and pulled upward gh a slit in the transverse mesocolon. A clamp is applied to it in the manner and it is left ready to take part in the gastro-enterostomy.

p 4.—Pull the mobilized stomach out of the abdomen. Apply an in- al clamp to the stomach close to the œsophagus and permit the clamp protected by gauze) to go inside bdomen. This clamp should short handles. It should be d to the stomach at right to the direction in which s are usually placed—that is, uld clamp the stomach trans- y. Cut an appropriate slit in e sheet of rubber dam. Pull obilized stomach through this nd spread the rubber dam as a tion over the whole territory ration so that no stomach con-

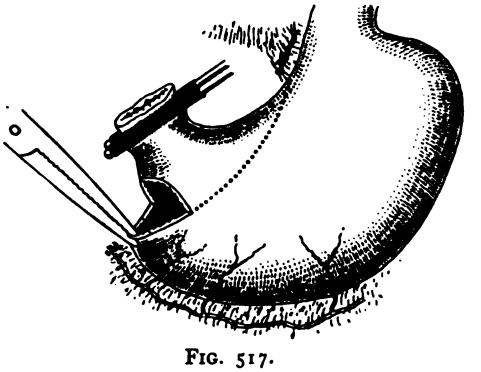


FIG. 517.

can soil the abdomen. The clamped jejunum can be palpated through ubber sheet and when it is needed the rubber can be incised.

p 5.—Make a free cut across the greater curvature at a point chosen so he tip of the greater curvature flap will easily extend to the point of n on the lesser curvature (Fig. 517). The gastro-epiploic vessels are of ligated at the point of section.

is the fact that both curvatures are sutured transversely that makes so much easier to suture and turn in than when one is dealing with a or a point. By this method the corners come in the free part of the ch where there is no tension.

hen the cut in the greater curvature is made, the latter is held up so hen it is divided nothing but gas will escape. Beginning on the greater ure near the pylorus cut through both the anterior and posterior walls

on a line directed towards the œsophagus and so excise the whole lesser curvature. At this point all of the stomach can be carefully cleaned out and inspected as far as the œsophageal clamp. If necessary the clamp can also be removed and still more of the lesser curvature excised. If the two main vessels are tied, the hemorrhage from the free edge may be ignored for a few minutes. Before completing the section it is well to apply forceps or a stout stitch to the stomach near the œsophagus and proximal to the line of section in order to insure against the stump slipping through the intestinal clamp. Ligate the coronary vessels.

Step 6.—Incise the rubber dam and secure the clamped loop of jejunum. Lay the greater curvature of the stomach at a suitable place over it having made a button hole in the posterior wall. Through this pull the loop of jejunum (the clamp remaining outside the stomach). Working inside the stomach, open the loop of jejunum and complete the gastro-enterostomy (exactly as in Maunsell's end-to-end enterorrhaphy) in the simplest possible manner. (Codman says that any method of suture suffices as long as the edges of the sutured wound project into the stomach; he believes that a single row of ordinary close sewing is enough.) Remove the clamp from the jejunum. If there is any bleeding from the gastro-enterostomy wound it is easily stopped by a stitch or two.

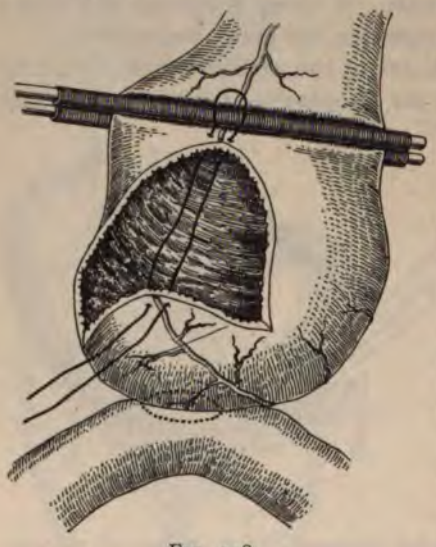


FIG. 518.

Step 7.—The greater curvature and adjacent stomach wall form a large flap, well nourished by the left gastro-epiploic vessels. With a mattress suture unite the end of the above flap to the upper end of the stomach wound in such a fashion that the coronary vessels and the distal divided end of the left gastro-epiploic vessels are encircled by the stitch and the edges of the wound are everted (Fig. 518). Complete the closure of the stomach by means of sutures so introduced that the wound is everted, that is, mucosa to mucosa. Remove the clamp controlling the gastric circulation. If any bleeding occurs it *must* be visible and so easily controlled because the edge of the wound is slightly everted. The preferable suture material is chromicized catgut.

Bury the everted line of sutures by a continuous layer of chromicized catgut sutures.

Step 8.—Remove the rubber dam and gauze protection. Restore the organs to the abdomen. Close the abdomen.

Codman claims for this operation that the lesser curvature can be removed up to the very edge of the œsophageal opening. By the use of a double-headed suture the flap made by the greater curvature is readily drawn up. The completion of the gastro-enterostomy has been made with ease and the

usual difficulty of attaching the jejunum to the stump is avoided. But the main point is that unsuspected soft ulcers may be detected when the stomach is open.

The presence of ulcers or of their sequelæ is the most common occasion for operations on the stomach. When ulcers are present, the lymph nodes corresponding to the diseased area are generally enlarged and form a good guide to the location of the disease.

Gastrectomy. *Partial gastrectomy.*—1. It is imperative to bury by suture or better to excise by knife or cautery every duodenal ulcer which bleeds easily or threatens to perforate. Hemorrhage is more common before operation in gastric than in duodenal ulcer, but hemorrhage subsequent to operation is more common in the case of duodenal ulcer. One cause of this peculiarity is undoubtedly that the fear of malignancy has led more frequently to excision of the gastric ulcer by knife or cautery. The following tables from the Mayo Clinic are striking.

TABLE 1.—HEMATEMESIS IN CASES OF DUODENAL ULCER IN WHICH OPERATION WAS DONE Jan. 1, 1906, to Jan. 1, 1918

	Cases, No.	Per cent.	Operative mortality from all causes, per cent.
Total number	2,875	....	1.6
Patients having hemorrhage before operation	583	20+	1+
Patients having hemorrhage before operation heard from	494	86.0	
Patients reporting hemorrhage after operation	63	12.7*	
Patients reporting hemorrhage after operation but none before	20	0.9	

* Or 2 per cent. of the total number.

TABLE 2.—HEMATEMESIS IN CASES OF ULCER OF THE STOMACH IN WHICH OPERATION WAS DONE

	Cases, No.	Per cent.	Operative mortality from all causes, per cent.
Total number	863	....	3+
Patients having hemorrhage before operation	222	25.8	4.8
Patients having hemorrhage before operation heard from	180	81+	
Patients reporting hemorrhage after operation	15	8.0*	
Patients reporting hemorrhage after operation but none before	2	0.3	

* Or 1+ per cent. of the total number.

2. It is hardly necessary to say that in cases of well-limited tumors of the stomach wall as well as in some cases of ulcer the diseased area may be removed and the wound closed by two layers of suture.

Balfour's cautery excision of duodenal ulcer is sufficiently explained (Figs. 519 and 520, Journ. A. M. A., Aug. 23, 1919). The line of suture may be reinforced by covering it by adjacent omentum. Of course this operation must be combined with gastro-enterostomy.

Excision of Saddle Ulcer.—When a saddle-shaped ulcer or any ulcer situated on the lesser curvature is excised, the manner of closing the wound is very important. If the resulting wound is closed in the long axis of the

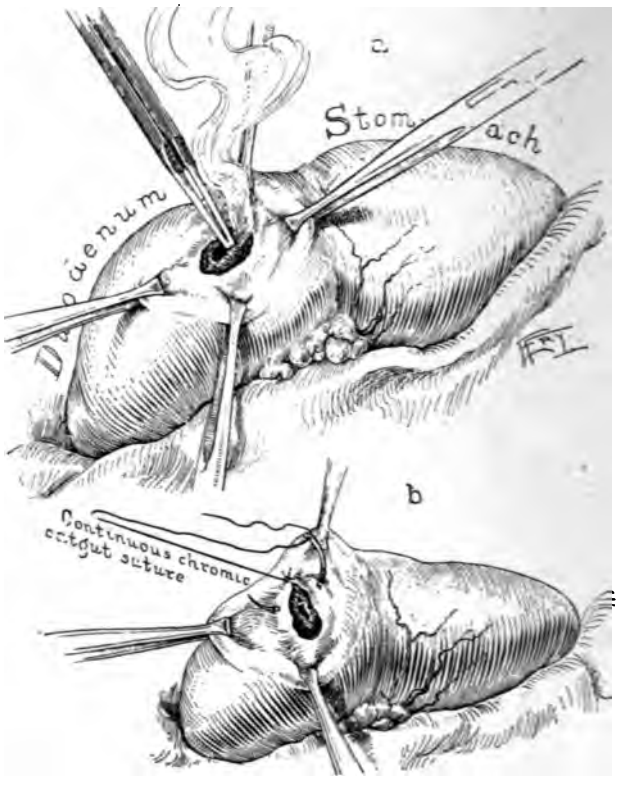


FIG. 519.—(*Balfour, Jour. A. M. A.*)

stomach, a certain amount of necessary contraction gives rise to an hour-glass stomach (Fig. 521), the wound must be closed transversely. A good way to operate is as follows:

Step 1.—On each side of the ulcer apply a ligature to the coronary vessels. Make a longitudinal slit in the gastro-hepatic omentum above the ulcer. Through this slit apply a volsella to the posterior wall of the stomach about ¾ inch beyond the posterior limits of the ulcer. At a corresponding point on the anterior surface of the stomach apply a second volsella. By lifting the volsellae, a transverse fold of stomach is brought forwards (and lies anterior to the gastro-hepatic omentum) consisting of the ulcer and portions of the anterior and posterior gastric walls.

Step 2.—Apply an intestinal clamp to the fold. The blades of the clamp are at right angles to the long axis of the stomach (Fig. 522).

FIG. 520.—(*Balfour, Jour. A. M. A.*)

FIG. 521.—Excision saddle ulcer. Wrong method.

Step 3.—Excise the ulcer. Payr dries the mucosa with gauze and paints it with tincture of iodine so as to lessen infection. Close the wound with catgut sutures applied in the Connel fashion. Remove the clamps. Apply a

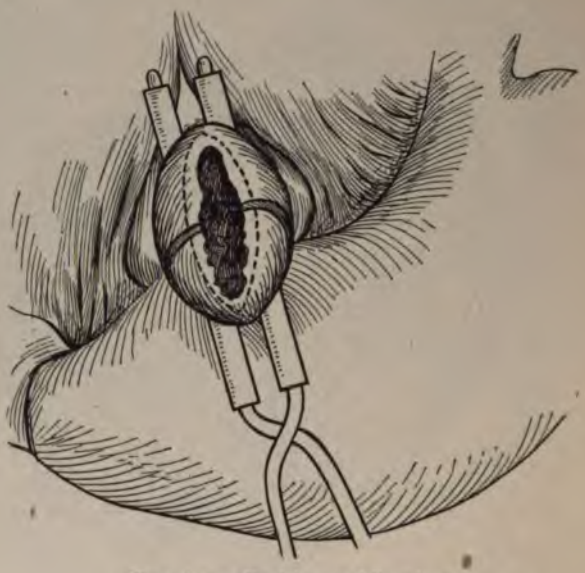


FIG. 522.—Excision saddle ulcer.

second row of sutures (fine chromicized catgut) in the Lembert fashion. The wound is so closed that its scar is transverse to the long axis of the stomach.

Step 4.—Close the wound in the gastro-hepatic omentum.

4. *Segmental or Sleeve Resection.*—Instead of this triangular excision of the ulcer a segmental or "sleeve" resection of the stomach may be adopted as it is believed to give a better result as regards gastric motility. (Stewart and Barber, Annals of Surg., Nov., 1916.

FIG. 523.—Segmental Resection.

Segmental Resection. *Step* 1.—Having exposed the stomach and the ulcer on its lesser curvature ligate the coronary vessels on each side of the ulcer and divide the gastro-hepatic omentum close to the ulcer. At corresponding points on the greater curvature ligate the gastro-epiploic vessels and divide the gastro-colic omentum between those points close to the stomach.

Step 2.—Apply intestinal clamps to the stomach on each side of the segment to be removed. Cut away the segment including the ulcer (Fig. 523).

Step 3.—Unite the proximal and distal segments of stomach as in any end-to-end anastomosis using fine chromicized catgut sutures. If the end of one

segment is longer than that of the other, place the sutures farther apart in the longer than in the shorter segment. Remove the clamps and repair any openings in the omenta.

Transgastric Partial Gastrectomy.—If an ulcer exists on the posterior wall of the stomach and is adherent to the pancreas it may be possible to gain access to it by penetrating both the gastro-hepatic omentum and the transverse meso-colon and then to divide the adhesions, excise the ulcer and close the wound in the stomach. W. J. Mayo has found it much easier in several cases to perform a transgastric operation as follows: Incise the anterior wall of the stomach by a vertical incision; note the extent of the ulcer and its adhesions; incise the posterior wall of the stomach from the inside around and close to the ulcer. Remove the ulcer, if necessary shaving off a thin surface of pancreas. This shaving of the pancreas is not so formidable as might be imagined, because the inflammation which has made it adherent to the stomach

FIG. 524.—Transgastric excision of ulcer on posterior wall of stomach.

has converted the adherent portion, to a large degree at least, into scar tissue. Close the posterior gastric wound by a row of serous sutures, then by a row of through-and-through chromicized catgut sutures (Fig. 524). Close the anterior wound in the stomach.

Pylorectomy and partial Gastrectomy.—Pylorectomy is almost always supplemented by a partial gastrectomy. The indications for its performance are usually malignant disease or pyloric ulcer and its sequelæ. Before operating on the stomach especially for cancer, it is of great importance to have a good working knowledge of the anatomy of the region, a knowledge which the standard textbooks on anatomy are careful *not* to give.

The gastro-hepatic or lesser omentum may be divided into three parts: (*a*) a thick, strong portion running from the liver to the cardiac end of the lesser curvature and part of the œsophagus (gastro-hepatic ligament), (*b*) a central or thin, often translucent portion, and (*c*) a thick, strong portion at and near the right end of the omentum and often named the hepato-duodenal ligament as it runs from the liver to the duodenum (Fig. 525). The hepato-

duodenal ligament is subject to variations which may be understood by t
descriptive names given to it, *e.g.*, cystico-colic ligament; cystico-duoden

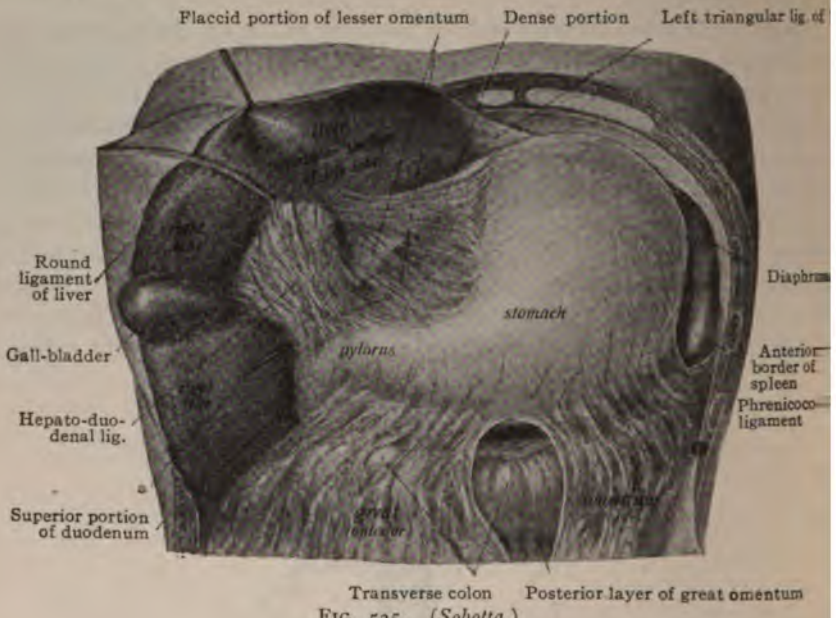


FIG. 525. (*Sobotta.*)

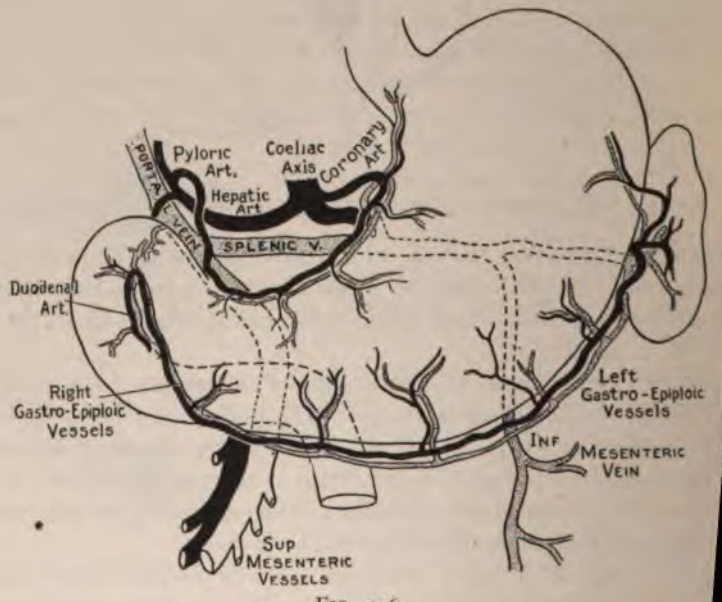


FIG. 526.

ligament; cystico-hepato-duodeno-colo-epiploic ligament (Tuffier and
"Revue de Gyn. et Chir. Abdom.," Jan., 1912). If a hole is torn th
thin or median portion of the gastro-hepatic omentum, the lesser

(antrum bursæ omentalis) is entered. Behind the peritoneum forming ıterior wall of the lesser cavity lies the cœliac axis which divides into ranches all of which are, to begin with, retro-peritoneal (Fig. 526). These es are (*a*) the splenic which passes to the left to reach the spleen. much of its course the splenic artery remains retroperitoneal lying above ınd the pancreas. Before reaching the spleen the vessel gives off the left epiploic artery which runs along the greater curvature of the stomach in tro-colic or great omentum to anastomose with the gastro-duodenal artery. e hepatic artery which passes retro-peritoneally to the right along the order of the pancreas for a short distance when it enters a fold of per- ı (hepatic fold) through which it reaches the lesser omentum (hepato- al ligament). In its course the hepatic artery gives off (1) the pyloric

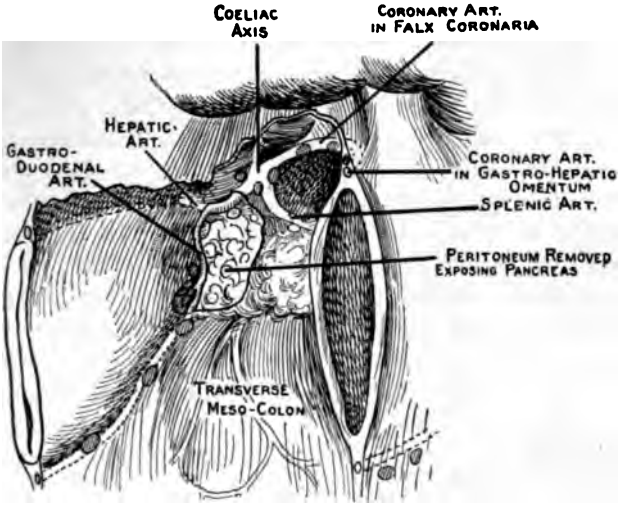


FIG. 527.

which enters the lesser omentum and runs to the left along the lesser ıre of the stomach to anastomose with the coronary artery, (2) the duodenal which runs downwards between the pancreas and the duodenum ter giving off a duodenal branch, passes in the gastro-colic omentum the greater curvature of the stomach to anastomose with the left epiploic.

The coronary or gastric artery which passes into the falx coronaria or pancreatic fold (Fig. 527) and through it reaches the lesser omentum e cardiac orifice of the stomach where, after sending a branch towards the ıgus, it runs along the lesser curvature of the stomach to anastomose with loric artery.

e folds of peritoneum which have been mentioned (gastro-hepatic fold, ear to the arteries a relation more or less similar to that of the mesentery ntestine.

the right portion of the lesser omentum (hepato-duodenal ligament) lie ft to right the hepatic artery, the portal vein and the bile ducts. If an

incision is made through the anterior layer of peritoneum forming the lesser omentum close to the pylorus it is easy to mobilize the pylorus and the gastric end of the duodenum without injuring the gastro-duodenal vessels or the common bile duct.

The lymphatics of the stomach have their ultimate roots in two systems:

1. Under the epithelium and surrounding the gland tubules there is a very rich plexus of lymphatic capillaries. From this plexus short vessels penetrate the muscularis mucosæ and join another rich plexus in the submucosa. In turn, the submucosal plexus drains through vessels penetrating perpendicularly the muscular tunics, into the subserous plexus.

2. Among the fibres of the musculature of the stomach another set of lymphatics arises and drains into the subserous plexus. There is free anastomosis between the lymphatics perforating the musculosa and those originating in the musculosa. The lymphatics of the mucosa and submucosa are truly capillaries—*i.e.*, they are endothelial tubes, are innocent of fibrous and muscular tunics and are not provided with valves. It is only in the large collectors of the subserous plexus that valves make their appearance.

The richness of the submucosal lymphatic plexus and its freedom from valves make it easy for infective or cancerous material to spread along the submucosal plane. There is such free communication between the lymphatics (submucosal and subserosal) of all areas of the stomach that, given obstruction to the flow through one set of collecting vessels, material injected into the subserous or submucous plexuses can readily travel in any direction from which the outflow is easiest. Thus, if the primary lymph nodes, through which a certain cancerous area of the stomach usually drains, become diseased and obstruct drainage then the drainage will take place by another route and the original disease spread in the submucosa. While the duodenal submucosa is very similar to that of the stomach, viz., a layer of loose connective tissue rich in lymphatics and blood-vessels, yet at the pylorus itself the connective tissue constituting it becomes condensed and poor in lymphatics, thus there is comparatively little direct lymphatic communication between the stomach and duodenum. The duodenal and gastric lymphatics, however, drain into the same lymph nodes and on their way to these nodes may anastomose, and so there may, on occasion, take place a retrograde flow of lymph from the gastric into the duodenal vessels. While this exchange of lymph may not be extensive yet it must be remembered. Clinically we know that cancer can spread from the stomach to the duodenum, but that this spread is not usually extensive and may be explained in part at least by the above anatomic facts.

From a practical point of view the surgeon is interested in knowing, first, how and in what directions gastric cancer spreads in the stomach walls so that he may make his lines of incision beyond those regions which may be reasonably considered affected, although no macroscopic evidence of disease may be present; second, in what directions the disease may have spread through the lymphatics so that he may excise all those lymphatic territories which may reasonably be considered involved.

The first of these questions has been fairly answered by the remarks already made regarding the lymphatic plexuses of the stomach and duodenum. For-

tunately the drainage from the pyloric and pre-pyloric portions of the stomach is so free that it is comparatively rare to find obstruction to it sufficiently extensive to dam back the infected lymph into the cardiac area, and it is cancer of the pyloric portion of the stomach which is of particular interest to the surgeon.

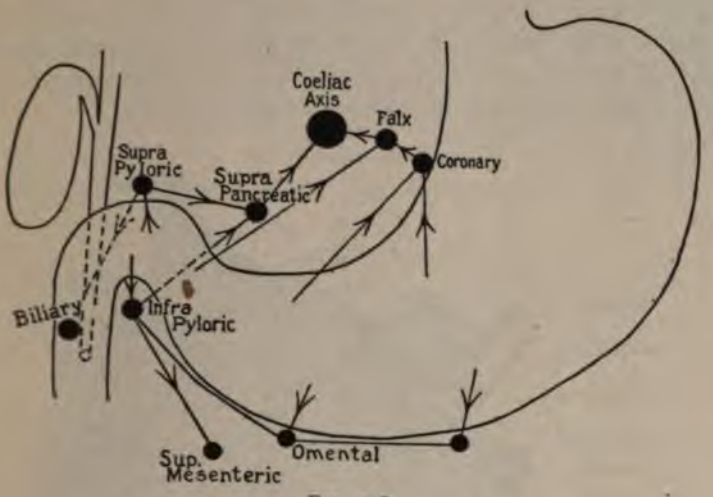


FIG. 528.

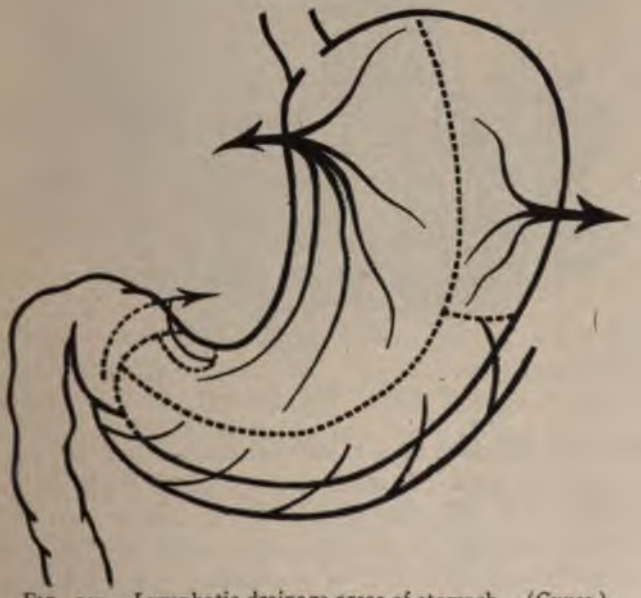


FIG. 529.—Lymphatic drainage areas of stomach. (*Cuneo.*)

The second practical question is much more difficult to answer. Practically all of the stomach drains ultimately into the glands near the celiac axis. The areas adjacent to the lesser curvature drain directly into glands along the coronary artery; the areas adjacent to the greater curvature drain into the gastro-colic glands which in turn pass into the subpyloric glands. The pylorus itself drains both upwards to the suprapyloric and downwards to the subpyloric

glands (Figs. 528, 529 and 530). Thus the subpyloric glands (Jamieson and Dobson, "Lancet," April 20, 1907) are a secondary group for the prepyloric region, but primary for the pylorus and duodenum. One or two vessels form the suprapyloric group pass behind the duodenum to low-situated nodes on the biliary chain.

The subpyloric group drain in two directions, (1) along the gastro-duodenal artery anterior to the pancreas to the middle superior pancreatic glands which accompany the hepatic artery before its division; (2) downwards in front of the pancreas to glands lying beside the superior mesenteric artery.

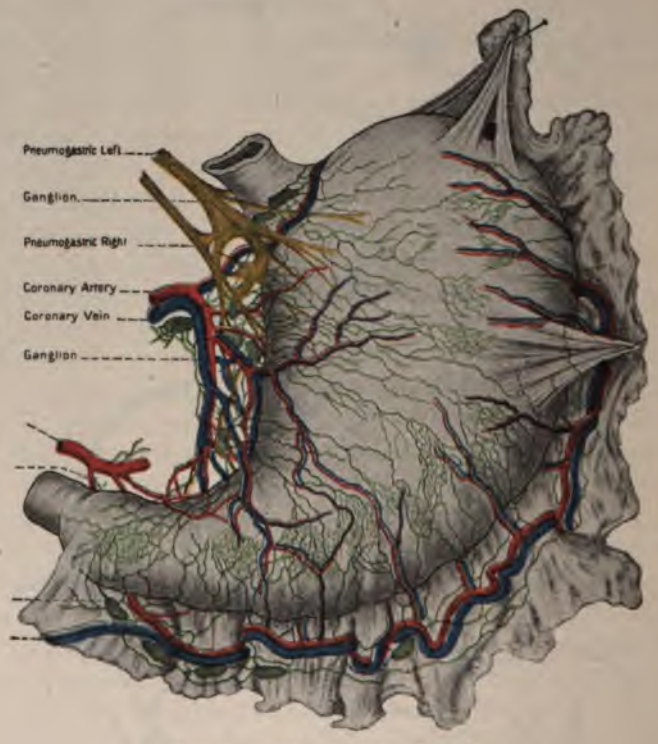


FIG. 530.—(*Mayo, after Cuneo.*)

Remember that the celiac axis is retroperitoneal, that the coronary artery in its course along the lesser curvature of the stomach lies in the gastro-hepatic or lesser omentum, but that that portion of the coronary artery between its origin in the celiac axis and its inclusion in the lesser omentum lies in the falx coronaria or gastro-pancreatic fold of peritoneum. A number of glands are present in this fold and through them drains the lymph from the glands in the lesser omentum. It must be remembered that certain of the lymph vessels arising near or at the pylorus pass along the lesser omentum, dodge the glands there present and pass directly into those of the falx coronaria. In operating for gastric cancer it is usually easy enough to remove with the disease the suspected lymphatics in the greater and lesser omenta and the subpyloric group, but the relation of the subpyloric vessels to the superior mesenteric group, the supra-

pyloric to the retro-duodenal biliary group and the direct route of drainage from the pyloric region to the glands in the falx coronaria are all elements threatening success in the radical operation for gastric cancer.

Malignant disease of the pylorus usually spreads towards the cardiac end of the stomach, especially along the lesser curvature; hence in operating in malignancy it is wise to excise along with the pylorus the whole lesser curvature of the stomach and all suspected lymph-glands. "In cutting across the stomach the incisions should be 1½ to 2 inches wide of the disease at least" (Mayo Robson). As malignant disease does not, as a rule, infiltrate towards the duodenum, the division of the duodenum may be made at a point about ¼ to 1 inch away from the disease. "In excising glands from the great

FIG. 531.—Lymphatics of stomach.

omentum there is great danger of wounding the middle colic artery and thereby causing gangrene of the transverse colon. The glands along the greater curvature are most numerous near the pylorus." (Mayo Robson, "Surg. Treatment Diseases of the Stomach.") This danger is avoided in the method described below.

In view of the facts stated in the preceding paragraphs, it follows that the original operations of pylorectomy were defective in extent. When a sufficiency of the viscus is removed, it will rarely, if ever, be possible to unite the open end of the duodenum to the open end of the stomach (partially closed by sutures), and when possible it will be much more difficult, time-consuming, and risky than the methods to be described.

Pylorectomy or Partial Gastrectomy.—*Step* 1.—Open the abdomen, usually by a longitudinal incision between the ensiform cartilage and the umbilicus. Explore the abdomen.

Step 2.—Tear a hole in the thin portion of the lesser omentum and through this hole feel the coronary artery as it passes in the falx coronaria (gastro-

pancreatic fold) into the lesser omentum near the œsophageal end of the lesser curvature of the stomach. With a full curved needle pass two ligatures round the coronary vessels (Fig. 532) and divide the vessels between them. Divide the lesser omentum except that thick portion of it called the hepato-duodenal ligament in which lie the bile ducts, the portal vein, etc. (N.B. The lesser omentum is usually sufficiently divided by the tear made in it during exposure of the coronary vessels. The portion of the omentum torn is avascular and innocent of lymph nodes.)

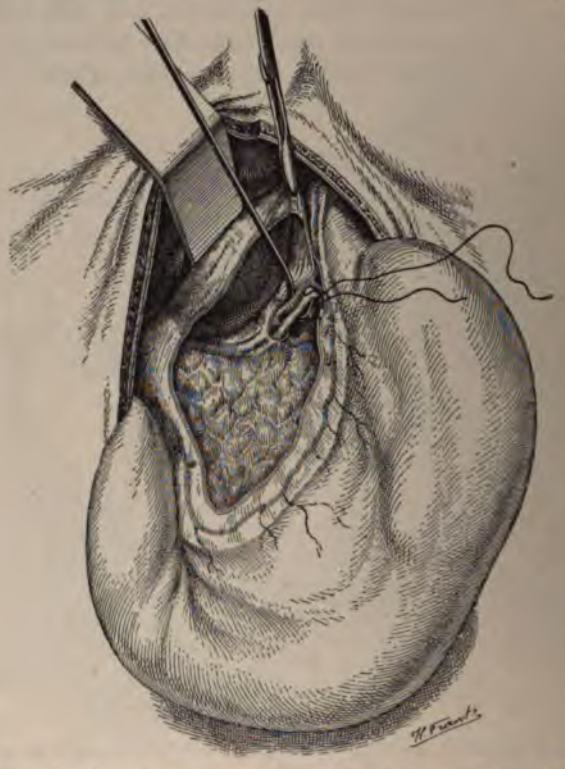


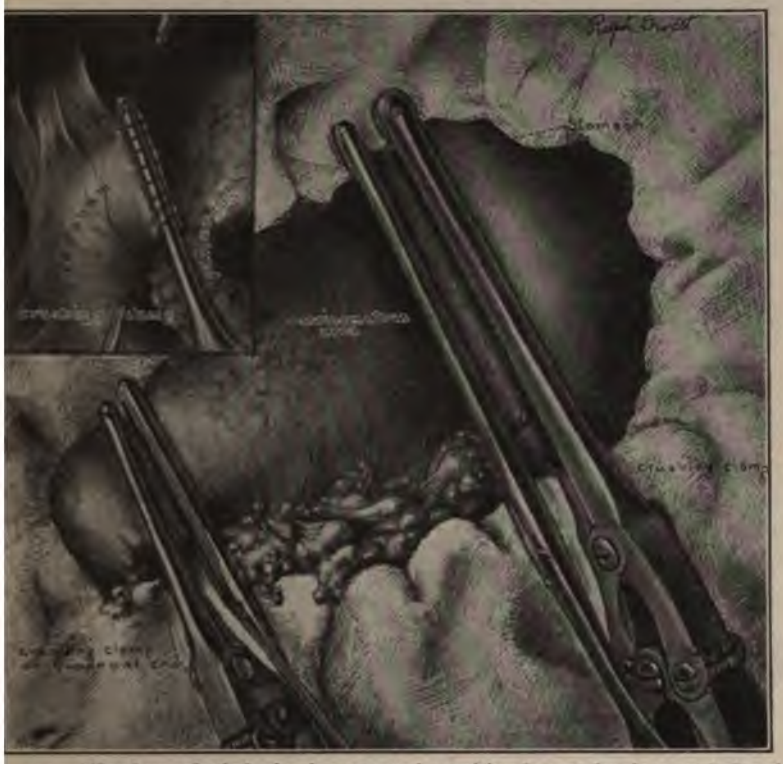
FIG. 532.—Ligation of coronary vessels in the falx coronaria. (*Guibé.*)

Step 3.—Divide the anterior layer of peritoneum forming the hepato-duodenal ligament and pass the finger round the duodenum from above downwards between the gut and the portal vein, bile ducts, pancreas, etc. Expose and tie the pyloric artery.

Step 4.—Pass the left hand from above downwards behind the pylorus and stomach and lift the great omentum forward. Ligate the right gastro-epiploic vessels. Ligate, in three or four segments, the great omentum. The hand behind the omentum protects the vessels of the transverse mesocolon from being included accidentally in the ligatures. Should this accident happen the devascularized transverse colon must of course be removed (enterectomy). Ligate the left gastro-epiploic artery well to the left of the disease and of the last of the glands in the great omentum if the disease is cancer. Divide the great omentum leaving attached to the stomach that portion containing lymph

As the gastro-colic omentum is being divided "it will sometimes be that the avascular area which lies in the circle of the middle colic vessels ıe posterior layer of the mesocolic peritoneum is attached to the growth. s is the case the attached peritoneum can be cut out and removed with rowth. The opening thus made in the transverse mesocolon can be ater through which to make the gastro-jejunostomy" (Mayo).

p 5.—Continue the division of the gastro-colic omentum towards the so as to get below and to the right of the inferior gastro-duodenal lymph situated below and to the right of the pylorus about the head of the as (Figs. 527, 528, 531). Lift up the fat and glands from over the head of



. 533.—Blood vessels tied, glands separated, crushing forceps in place, and also clamps ent leakage from part to be removed. Upper left drawing shows stump of duodenum hing clamp with suture placed for closing. (*Mayo.*)

ıncreas separating them from the curve of the duodenum but leaving them ıed to the stomach and pylorus. During the above dissection the vessels ɔmosing with the branches of the superior pancreato-duodenal artery are ed and tied. Continue the dissection until at least 2 inches of the in- border of the duodenum is cleared and the gastro-duodenal artery is ed in the groove between the head of the pancreas and the duodenum. and divide the gastro-duodenal vessels. This permits thorough re- l of the glands.

p 6.—If the gastric growth is adherent to the pancreas, shave off a n of the pancreas leaving the shaved-off portion attached to the stomach.

pancreatic fold) into the lesser omentum near the œsophageal end of the lesser curvature of the stomach. With a full curved needle pass two ligatures round the coronary vessels (Fig. 532) and divide the vessels between them. Divide the lesser omentum except that thick portion of it called the hepato-duodenal ligament in which lie the bile ducts, the portal vein, etc. (N.B. The lesser omentum is usually sufficiently divided by the tear made in it during exposure of the coronary vessels. The portion of the omentum torn is avascular and innocent of lymph nodes.)

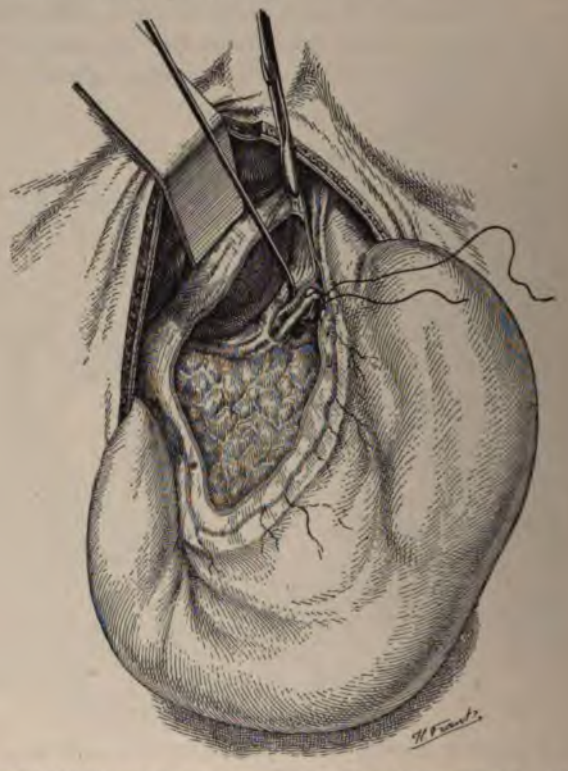


FIG. 532.—Ligation of coronary vessels in the falx coronaria. (*Guibé.*)

Step 3.—Divide the anterior layer of peritoneum forming the hepato-duodenal ligament and pass the finger round the duodenum from above downwards between the gut and the portal vein, bile ducts, pancreas, etc. Expose and tie the pyloric artery.

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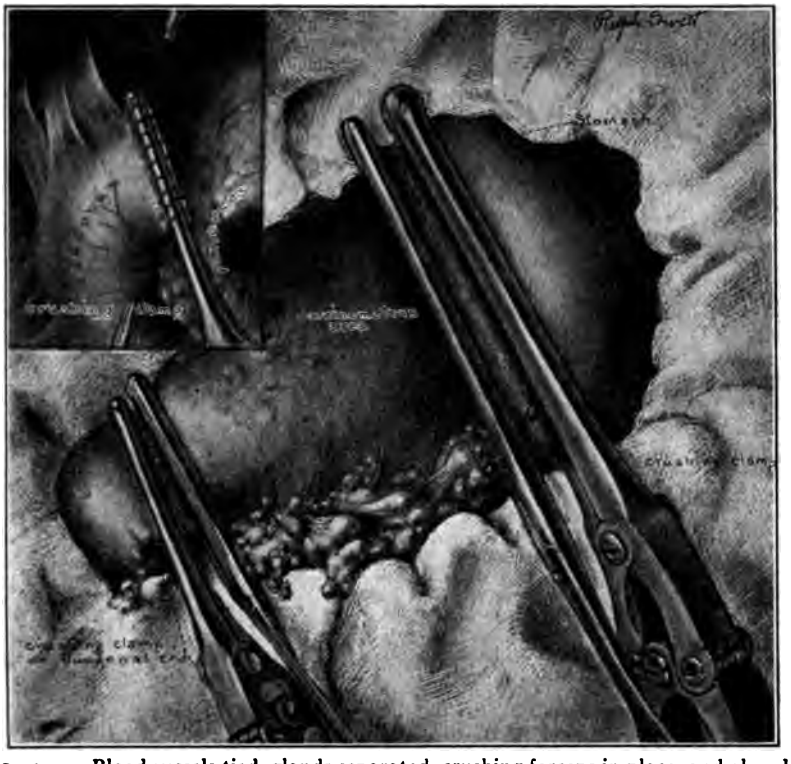
s. As the gastro-colic omentum is being divided "it will sometimes be d that the avascular area which lies in the circle of the middle colic vessels the posterior layer of the mesocolic peritoneum is attached to the growth. iis is the case the attached peritoneum can be cut out and removed with growth. The opening thus made in the transverse mesocolon can be later through which to make the gastro-jejunostomy" (Mayo).

tep 5.—Continue the division of the gastro-colic omentum towards the : so as to get below and to the right of the inferior gastro-duodenal lymph s situated below and to the right of the pylorus about the head of the reas (Figs. 527, 528, 531). Lift up the fat and glands from over the head of



G. 533.—Blood vessels tied, glands separated, crushing forceps in place, and also clamps vent leakage from part to be removed. Upper left drawing shows stump of duodenum shing clamp with suture placed for closing. (*Mayo.*)

ancreas separating them from the curve of the duodenum but leaving them hed to the stomach and pylorus. During the above dissection the vessels tomosing with the branches of the superior pancreato-duodenal artery are sed and tied. Continue the dissection until at least 2 inches of the in- r border of the duodenum is cleared and the gastro-duodenal artery is sed in the groove between the head of the pancreas and the duodenum. te and divide the gastro-duodenal vessels. This permits thorough re- al of the glands.

tep 6.—If the gastric growth is adherent to the pancreas, shave off a on of the pancreas leaving the shaved-off portion attached to the stomach.

If the involvement of the pancreas is extensive "it is better to leave this part of the operation until the stomach is either cut across and separated from the duodenum or stomach section on the cardiac side is finished and the stomach turned over in order that this portion of the dissection may be completed under inspection. If such injuries to the pancreas are properly cared for, we have not found that they give rise to serious consequences. . . . The best manner of treating such an injury to the pancreas is to cover it as far as practicable with the sheath and posterior peritoneum, and after completely closing the end of the duodenum, if possible the stump of the duodenum should be buried in the injured surface of the pancreas" (Mayo).

FIG. 534.—Crush clamp on stomach. Cautery used to sterilize and prevent carcinomatous implantation. Stump of duodenum closed. Sutures placed to turn the duodenal stump into the denuded head of the pancreas. (*Mayo.*)

Apply two clamps to the duodenum distal to the disease and about ½ inch apart. The distal clamp should be a very powerful crushing one like Payr's; for the proximal segment of gut any efficient clamp, such as Ochsner's, will serve. Cut between the clamps with a cautery and burn the stumps protruding from the clamps even to such an extent that the Payr's clamp is heated sufficiently to char the tissues crushed between its jaws. Insert a continuous fine chromic catgut suture, in the Cushing fashion, the bites being alternately on each side of the clamp and the threads crossing it (Fig. 533).

Remove the Payr's clamp, pulling its blades out from under the threads. The divided duodenum is so crushed and charred that it remains closed. Pull

on the ends of the suture. As tension is put on the suture the wound becomes inverted as by a continuous Lembert suture. Fasten the ends of the suture. Put in an extra line of mattress sutures to reinforce the closure. Suture the duodenal stump to the area of pancreas denuded during the mobilization of the duodenum or to the edge of the fascia which covered the pancreas.

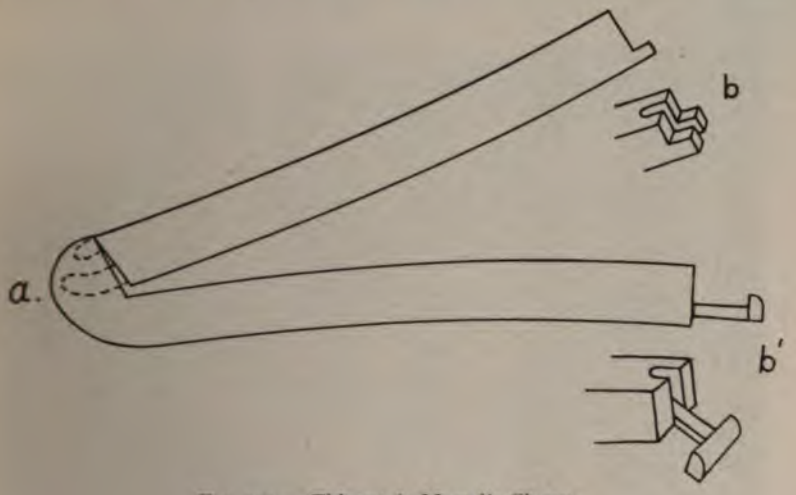


FIG 535.— Thierry de Martel's Clamp.

Thierry de Martel (La Pr. Med., July 7, 1910) uses a powerful clamp which crushes evenly. Figs. 535 and 536 sufficiently explain it. Two of the clamps are applied to the duodenum and two to the stomach, section of the viscera being made between each pair of instruments; de Martel applies an ordinary intestinal clamp to the intestine before removing the crushing clamp and closes the viscus with two layers of suture.*

FIG. 536.—Forceps for closing de Martel's clamp.

Step 7.—Choose the line of section on the stomach to the left of the lymphatic glands into which the diseased area drains (Figs. 529, 530, 531). To the cardiac side of this line apply Payr's large crushing clamp; to the pyloric side apply any efficient clamp. Divide the stomach between the forceps with the cautery and remove the diseased segment. Insert a chromicized catgut suture in the stomach stump exactly as was done in the duodenal stump, tightening the suture as the Payr's clamp is removed. Reinforce the line of suture by a few mattress or Gould sutures of chromicized catgut and bury these by a line of interrupted sutures.

Step 8.—Perform a posterior gastro-jejunostomy.

If the portion of the stomach left after excision of the disease is very small

* Since this was written de Martel has devised a double clamp which seems convenient though not essential. (L. Pr. Med., June 30, 1920.)

it might be technically difficult to perform gastro-jejunostomy and the second operation might well jeopardize the nutrition of the gastric stump. To avoid these evils the latter part of Step 7 may be modified by using a method of anastomosis credited by Mayo to Pólya and by Bier to Krönlein. Instead of closing the gastric stump as described above, anastomose it to the side of the jejunum as follows: Make an opening in an avascular portion of the transverse

FIG. 537.—Upper jejunum, 6 to 12 inches from origin, brought through an opening which has been made in the transverse mesocolon and united by outer row of sero-muscular chromicized catgut sutures to posterior wall of stomach. (*Mayo.*)

mesocolon; pull the upper jejunum through this opening and lay it along side the stomach stump without tension. Balfour (Surg., Gyn. Obst., Nov., 1917) prefers to select a loop of jejunum 14 to 18 inches below the duodenojejunal junction and bring this loop *anterior* to the transverse colon so as to reach the stomach stump without perforating the mesocolon. Apply an intestinal clamp to the loop of jejunum exactly as in gastro-jejunostomy. Unite the jejunum to the posterior wall of the stomach behind the Payr's clamp by a row of chromicized catgut sutures (Lembert or Gould sutures) (Fig. 537).

Apply an intestinal clamp to the stomach proximal to the line of serous sutures. Remove the Payr's clamp. Unite the open end of the stomach to a

nding opening now made in the jejunum, by a row of through-and-sutures of chromicized catgut, exactly as in gastro-jejunostomy (Figs. 539). Remove the intestinal clamps and introduce the anterior row of ized catgut Lembert sutures. Draw the entire anastomosed end of the

—Crushing clamp removed from the stomach and holding clamps applied to jejunum and stomach to prevent soiling. (*Mayo.*)

down through the opening in the transverse mesocolon. Unite the the opening in the mesocolon to the stomach wall (Fig. 540). Some- is not easy to pull the jejunum up to the upper end of the opening in the or to keep it there without tension. Under these circumstances it is apply an intestinal clamp well back of the Payr's clamp and after re-

moving the latter to close the upper end of the gastric opening by two rows of suture and then to anastomose the side of the jejunum to the low part of the stomach opening. When this is done it is well to suture the jejunum to the

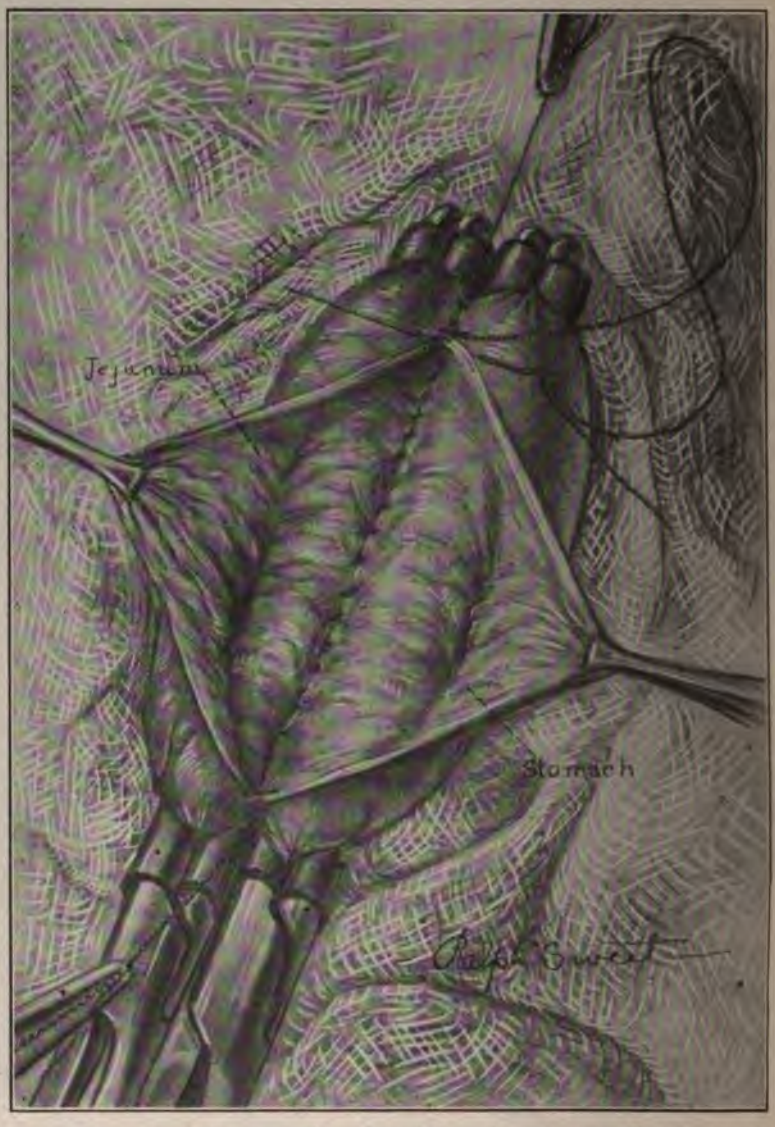


FIG. 539.—Inner row of catgut through-and-through sutures applied to the posterior walls, uniting jejunum to cut end of the stomach and continuing part way down the anterior wall. (*Mayo.*)

stomach for a short distance above the site of anastomosis so that the unopened jejunum acts as a patch applied to a part of the line of suture closing the stomach (Fig. 541).

Moynihan's Technic.—The sequence of steps in the operation as performed by Moynihan is as follows:

The belly having been opened and parts exposed.

(*a*) Divide the duodenum between crushing clamps. Catch and ligate vessels individually. Find and remove the subpyloric (subduodenal) lymph nodes which lie near the second part of the duodenum.

FIG. 540.—Anastomosis completed by an anterior row of sero-muscular sutures. Anastomosed end brought through the opening in transverse mesocolon, and margins of opening sutured to the stomach. (*Mayo.*)

(*b*) Divide, between ligatures, the gastro-colic omentum.

(*c*) Divide, between ligatures, the gastro-hepatic omentum as high up as possible. Ligate the coronary artery late; this permits access to it at a high level and gives access to some high lymph nodes into which lymphatics drain directly from the pyloric region. Remove the nodes.

(*d*) Tear a hole in the mesocolon and pull a loop of jejunum through it. Perform posterior gastro-enterostomy using the cardiac portion of the stomach.

The anastomosis is more easily performed before rather than after excising the portion of stomach to be removed.

(*e*) Choose the line of section on stomach. Put in a stay or traction suture on the lesser curvature well proximal to the line of section. Apply a clamp to the stomach ¾ inch proximal to the line of section and distal to the stay suture which forms a great safety if the clamp slips.

(*f*) Divide the stomach with the cautery.

(*g*) Suture the mucosa with catgut. Apply two layers of continuous Lembert (Cushing) sutures, after removing the clamp.

(*h*) Fix the cut edge of the gastro-colic omentum to the lower end of the stomach.

FIG. 541.—The stomach has been closed from the lesser curvature to the point *A*. *A.B.* is the site of anastomosis. *A.C.*, a portion of jejunum acting as a patch over Billroth's fatal angle.

(*i*) Attend to the duodenal stump in the usual fashion and then attach it by a stitch to the anterior surface of the pancreas.

(*j*) Pull the great omentum up in front of the transverse colon and tuck it into the cavity now existing above the colon.

Pauchet's Gastrectomy.—Pauchet (La Pr. Med., Oct., 9, 1916 Sherwood Dunn, Am. J. of Surg., Oct., 1916) is a great advocate of the intercoloepiploic route for exploring the posterior gastric and duodenal walls, for operating upon lesions of these walls as well as upon ulcers of the lesser curvature.

Step 1.—Open the abdomen. Pull the great omentum and the transverse colon out of the abdomen and reflect them upwards. If slight traction is made upwards on the omentum and downwards on the colon numerous delicate peritoneal folds will be seen passing from omentum to colon. Divide some of these folds carefully close to the gut and begin separating the omentum from the colon by scissors guided by the finger introduced through the original cut. As soon as possible enter the lesser peritoneal cavity. Turn the stomach with the attached omentum upwards, thus exposing the whole posterior surface of the stomach and doudenum as well as the pancreas (Fig. 542, 543, 544, 545).

In case of a bullet wound of the stomach the anterior wound may be sutured, the posterior wound found by inter-colo-epiploic separation and sutured. The great omentum may now be packed into the lesser peritoneal cavity and the inferior border of the stomach sutured directly to the colon along the line of its separation from the great omentum.

—(There is extensive ulcer of the lesser curvature, or hour glass
s present.) Ligate the coronary and gastro-epiploic vessels proxi-
distally to the segment of stomach to be removed.
—Choose the lines of section necessary for removal of the affected
the stomach. Apply a crushing clamp to the stomach on each side
al line of section and divide the stomach between them with the cau-

-Separation of omentum from transverse colon. (*Lardennois, Journ. de Chir.*)

n the pyloric stump protruding from the clamp until the clamp is
iciently to char the tissues crushed between its jaws (p. 398). Insert
us fine chromic gut suture in the Cushing fashion, the bites being
on each side of the clamp and the threads crossing it. Remove the
ull on the ends of the suture until the wound becomes neatly inverted
ntinuous Lembert suture. Fasten the ends of the suture and rein-
number of mattress sutures. Similarly apply crushing clamps to
f the proximal line of section and proceed exactly as described on
steps 7 and 8. If the disease is cancer, after carrying out step 1

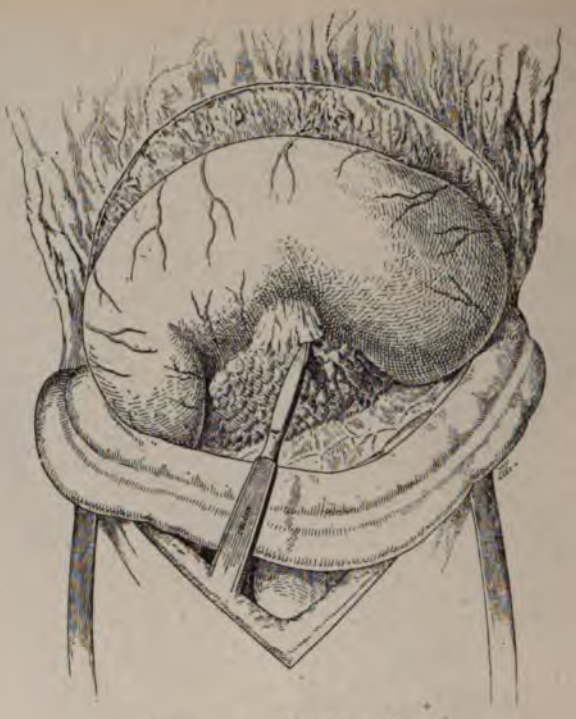


FIG. 543.—(*Pauchet & Dunn.*)

FIG. 544.—(*Pauchet & Dunn.*)

follows: Working from below upwards by sharp dissection, separate ɔus pylorus from the pancreas and mesocolon (Fig. 544). 'There y not be oozing of blood during this step but there will not be real e.'

—Mobilize the duodenum down to the pancreas. Ligate the vessels he upper and lower borders of the duodenum. Crush, divide and ıodenum as described on p. 398. As a precaution cover the duodenal ı a cap made from remnants of the gastro-hepatic omentum or of tum. This may be done at a later stage of the operation but should tted.

—Complete the operation as described on p. 399.

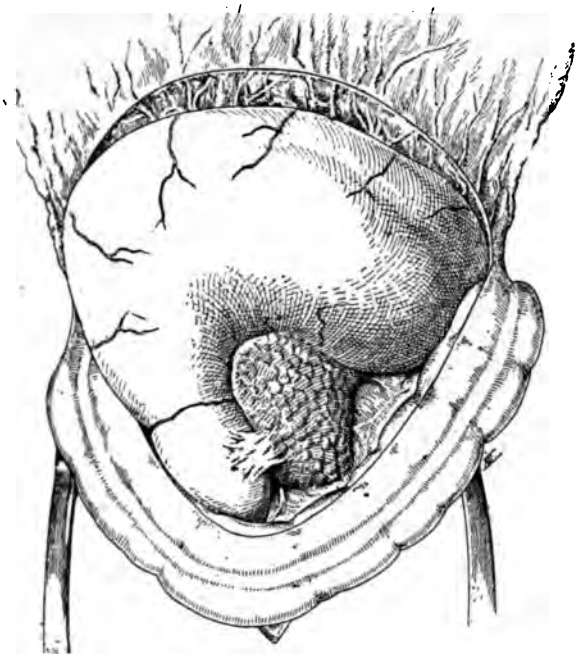


FIG. 545.—(*Pauchet & Dunn.*)

eatment.—The special rules for the after-treatment of stomach opera- ıhortly, as follows:

the patient is much dehydrated, give intravenous or subcutaneous ɔf saline solutions. These may be repeated during a few days if

If not dehydrated and if stimulation is necessary, administer sub- y a 20 per cent. solution of camphor in sterile olive oil. As the ıves the operating-table 8 ounces of warm coffee should be given n. Murphy's proctoclysis is excellent. Transfusion of blood is e-saving value. Morphine in an efficient dose may be administered

soon as the effects of the anesthetic wear off (within a few hours) ɔatient into a sitting or rather semi-sitting posture. This tends to lmonary disturbances and is important.

(*c*) Small doses of hot water or tea may be given as soon as nausea is overcome. Water, if well born by the stomach, is of great value.

(*d*) It is usually safe to give liquid food twelve hours after operation. If the stomach is troublesome rectal feeding must be practiced.

(*e*) These rules are possibly too conservative. Roux permits his patients to eat almost anything they desire as soon as they desire after gastroenterostomy.

Ultimate results of resection of the stomach for cancer.

Out of ninety-four cases which survived three years or longer and which were without recurrence at the beginning of the third year only five suffered from later recurrence. Of the remaining eighty-nine cases the cures had persisted sixteen years in one, ten years in five, and from five to ten years in thirty-four. The hope of permanent cure, according to Leriche's figures, is about 20 per cent. [Leriche, "Rev. de. Med.," Feb., 1906. Ref. "Zentralblatt für Chir.," 1907, No. 29.]

The Mayos' statistics of partial gastrectomies and pylorectomies performed between April, 1897, and January, 1910, are as follows:

Number of operations 266 with thirty-four deaths (12.4 per cent.). Forty-two of the operations were *not* for cancer. During 1909 there were forty-six operations with four deaths (8.6 per cent.).

Operations for carcinoma involving the pyloric end of the stomach:

Total number, 224. Average age, 53.

Patients operated on over five years ago: Total number, 50. Present condition known, 39. Alive and well: one 8 years, 2½ months; one 8 years; one 7 years 2 months (has since died of recurrence); one 6 years; one 6 years, 11 months; one 5 years, 3½ months; one 5 years. Total, 8.

Patients operated on over four years ago: Total number, 85. Present condition known, 64. Alive and well, 13.

Patients operated on over three years ago: Total number, 117. Present condition known, 88. Alive and well, 18.

Patients operated on less than three years ago: Total number, 107.

In one case of gastric carcinoma operated on by the author the stomach was inseparably adherent to the abdominal wall at the umbilicus and also adherent to the pancreas. The umbilicus was excised along with most of the stomach. Three years after the operation the patient was well.

(B) *Complete gastrectomy* is indicated when the whole stomach is affected by malignant disease; or if only one part is evidently affected, the rest is in a suspicious condition. It is useless to attempt a complete gastrectomy if neighboring structures are involved. Connor first performed this operation in 1889. The patient lived forty-eight hours. Schlatter subsequently and independently operated; his patient died one year afterwards from recurrence.

The Operation.—Open the belly in the middle line by an incision extending from near the ensiform cartilage to the umbilicus. Divide the greater and lesser omenta after securing their vessels by chain ligatures. The stomach remains attached to the body by the œsophagus and duodenum. Pull the œsophagus downwards as far as possible and apply a clamp to it at as high a point as can be reached. Clamp the cardiac orifice of the stomach. Divide

e œsophagus between the clamps. Apply two clamps to the pyloric end the stomach or to the duodenum and divide between them. Remove the omach. Close the open end of the duodenum by a continuous through-d-through suture covered by a row of Lembert sutures, interrupted or con-nuous. Approximate a loop of jejunum to the open end of the œsophagus. nastomose the œsophagus and the portion of gut selected by suture or by e Murphy button. Of course, if the open end of the duodenum can be pproximated to the œsophagus without undue tension, then these structures ught to be united. (Harvie, "Annals of Surg.," 1900, p. 344.)

Excision of Cardia and Abdominal Œsophagus.—H. Boit (Zent. für Chir., xvi, May, 914) has frequently successfully operated on dogs and once unsuccessfully on man, in the llowing manner:

Anesthesia by the Sauerbruch or Meltzer-Auer method.

"Left dorsal flap incision with base near spine. Temporary division of the ribs from e eighth to twelfth near the longitudinal muscles of the back. Longitudinal opening of e pleura and peritoneum. Intercostal incision in the seventh interspace with retraction the wound in chest. Division of the tendinous diaphragm up to the cardia. Separation the cardiac end of the stomach and of the affected œsophagus. Division of both vagi mediately above the diaphragm. The stomach and œsophagus can now be pulled out the wound and the operation carried on outside of the body. Completely protect the st cavity, mediastinum and abdomen with pads. Resect a segment of stomach and ophagus. To avoid subsequent stenosis divide the œsophagus obliquely. Close the wound the stomach. Make an anastomosis between the fundus of the stomach and the stump the œsophagus using two rows of *interrupted* sutures. Suture both halves of the divided phragm over the line of anastomosis in such a way as to provide the latter with a per-neal covering. Close the diaphragmatic and mediastinal wounds. Close the chest under perpressure." The great danger apart from shock consists in suture insufficiency. This prevented by avoidance of too great dissection of the œsophagus, avoidance of tearing and shing of the œsophageal stump and in avoidance of tension on the sutures. Usually the eration must be preceded by jejunostomy to permit of nourishment being given. During e laparotomy the abdomen must be explored to determine if the major operation is justifiable.

CHAPTER XXXIV

OPERATIONS ON THE INTESTINES

Apart from operations which are essentially directed against the biliary assages, or from the operation of gastro-duodenostomy, the only lesion ommonly calling for interference with the duodenum is ulceration. Duo-enal ulceration is much more common than is usually supposed and has been argely dealt with in the chapter on ulceration of the stomach. The opera-ive treatment depends on the presence or absence of perforation.

Perforation of the Duodenum.—The ulcer is almost invariably situated n the first 2½ inches of the gut, and is, therefore, accessible.

Step 1.—Open the abdomen by the right rectus incision. Guided by vidences of inflammation and by anatomical knowledge, expose the disease.

Step 2.—Cleanse the affected area. Protect the rest of the belly with uze. If possible, close the perforations by Lembert sutures. Reinforce

the suture by an omental graft. If possible make the line of suture transverse to the long axis of the bowel; this to avoid stricture. In one case H. S. Clogg ("Brit. Med. Jour.," Jan. 2, 1905), unable to close the perforation by sutures, brought up the free edge of the omentum and stitched it around the perforation with excellent effect. One must remember, however, that this procedure might form the excuse for the occurrence of an internal hernia. A free, *i.e.*, non-pedunculated omental graft is entirely preferable. Murphy writes: "Where the intestinal wall is indurated and adherent to neighboring tissues it must be sufficiently liberated and freed to admit of an easy apposition of its convex surfaces with two rows of suture. The failure to free the intestine from neighboring structures is the most common cause of failure of union."

Step 3.—Provide for drainage through the primary incision; through a special opening made in the right loin just below the last rib, or when there is much peritonitis, provide pelvic drainage through an anterior wound and keep the patient in the Fowler position.

When the patient's general condition is good, it might be wise to follow Step 3 by performing a gastro-enterostomy so as to give rest to the duodenum and permit healing of the ulcer.

Corner has treated duodenal and gastric perforations by mere plugging with a strip of gauze. This seems a very risky procedure as a duodenal fistula does not tend to close spontaneously and unclosed is invariably fatal.

A. A. Berg recommends treatment of duodenal fistulæ by means of gastro-enterostomy *plus* pyloric occlusion. This is thoroughly logical. Pannett (Lancet, April 18, 1914) in a case of duodenal fistula when the patient was *in extremis* from starvation, established a jejunostomy after the Witzel method, at the same time anastomosing the loop of jejunum going to, with that coming from the jejunostomy opening. Pannett claims the following advantages for jejunostomy: "it is technically a simpler operation, because there are few or no adhesions to be dealt with; a septic area of the abdomen has not to be opened up; the normal functioning of the pancreas is not interfered with by hindering the formation of the hormone of the pancreas (secretin), which occluding the pylorus does.

The disadvantage lies in the fact that a subsequent gastro-jejunostomy, should it become necessary, would be a very difficult and complicated procedure. Nevertheless, I think this operation will become the method of choice, and Mayo has found that very few perforated duodenal ulcers subsequently need a gastro-jejunostomy."

Duodenal Ulceration without Perforation.—The treatment of ulceration and its sequel, stenosis, has been dealt with in the chapter on gastric ulcers.

Duodeno-jejunostomy.—Chronic obstruction due to trouble at the duodeno-jejunal angle may call for an anastomosis between the duodenum and the jejunum. The distal portions of the duodenum are normally immobile and thus unless mobilized are inconvenient of access. Kummer ("Bul. et. Mem. Soc. de Chir. de Paris," xlvi, 1161, Oct., 1920) advises mobilization of the last (fourth or ascending) portion of the duodenum through Clairmont's incision ("Beitr. z Klin. Chir.," lxxi, 509). Pull the transverse colon upwards; retract the small intestines upwards and towards the right. This exposes

the duodeno-jejunal junction. Beginning at the inferior duodeno-jejunal fold make a vertical incision downwards through the posterior parietal peritoneum and through this mobilize the gut. The rest of the operation requires no special description.

Enterotomy and Closure of Intestinal Perforations.—Enterotomy is the operation performed for the extraction of foreign bodies or for the evacuation of intestinal contents in certain cases of obstruction where enterostomy is not indicated. As the closure of the gut after incision is similar to the procedure required in perforation, the two subjects may be treated together.

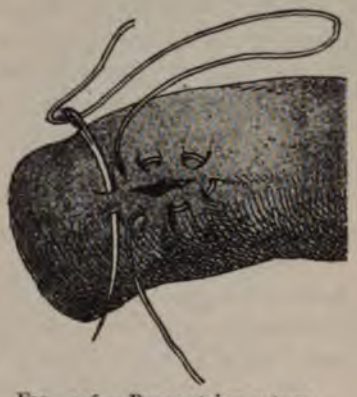


FIG. 546.—Purse-string suture. (*Monod and Vanverts.*)

Step 1.—Expose the intestine by an incision in or near the median line. Exceptionally some other incision is preferable.

Step 2.—Find and pull out of the belly the loop of gut to be attacked. (If the case is one of perforation, empty the loop by stripping it with the fingers and apply clamps or their equivalent.) Protect the belly cavity with pads.

Step 3.—Make a longitudinal incision through the intestinal wall on the side opposite to the mesenteric attachment. Extract the foreign body. Undoubtedly a longitudinal incision when closed narrows the gut lumen more than does a transverse, but the amount and danger of this narrowing have been much exaggerated and the longitudinal cut is the more convenient and practical.

Step 4.—Closure of the intestinal wound.

(A) If the opening is very small, one or two points of Lembert sutures will suffice, or a purse-string suture may be better (Fig. 546).

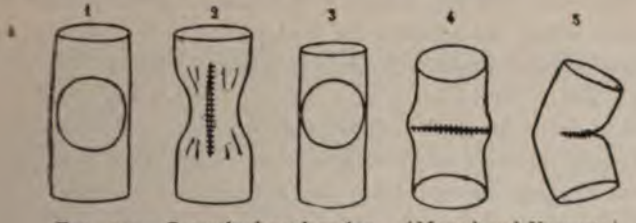


FIG. 547.—Intestinal perforation. (*Monod and Vanverts.*)

(B) If the opening, while longer, is linear, insert a row of continuous through-and-through sutures for hemostasis and occlusion (Connell's Structure is good), and cover these by a line of Lembert sutures, either continuous or interrupted. Some surgeons do not use the deep row of sutures, but it is both a convenient and a safe procedure.

(C) If the opening is large, or so contused or diseased that sutures close to it will not hold, direct closure, whether transverse or longitudinal, leads to serious obstruction (Fig. 547). The effects of the resulting stenosis may be discounted by making an anastomosis between the loop of gut leading

to and that going from the stenosis, or the injured segment of intestine may be excised.

Step 5.—Cleanse the exposed gut. Review the line of suture reinforcing it, where necessary, by points of Lembert sutures. Remove the protective pads. Replace the intestines in the belly.

Step 6.—Close the belly.

If there is any fear that the intestinal sutures will fail to do their duty, many, probably most, surgeons apply a wick of gauze or cigarette drain to the wounded gut, bringing the free end of the drain out through the parietal wound. To the writer it appears that such a precaution is liable to lead to the very state of affairs it is meant to prevent; that the foreign body or drain close to the line of suture may possibly interfere with the process of repair.

Lateral Anastomosis by Means of Suture.—The following operation is in all essentials that described by Abbé:

Step 1.—Bring outside the abdominal cavity, which is protected by gauze pads, the loops of gut to be united. Place the loops together in such a manner that about five inches lie in contact. Squeeze the contents out of the loops and apply suitable clamps to keep them empty.

Step 2.—Unite the two loops of gut for about four inches by a row of continuous suture (continuous Lembert), parallel to and not far from the mesenteric border. The stitches involve the serous, muscular, and fibrous or sub-mucous tunics. Fasten the suture with a knot (Fig. 548). The objection to continuous non-absorbable sutures when used in gastro-enterostomy does not apply in the case of the intestine where if the suture causes any irritation it is promptly sloughed into the gut and no harm results.

Step 3.—At a safe distance from the line of suture A, B, make the opening X, Y, in one of the loops. The opening must be about one inch shorter than the line of suture A, B. A portion of intestinal wall about one-half inch in width may be excised along the line of the opening X, Y. This, however, is optional. Seize any bleeding points with forceps. Payr ("Zent, für Chir.," March 23, 1912) wipes the mucosa dry and paints it with tincture of iodine. This sterilization of the mucosa he finds to be very useful. Repeat Step 3 on the other loop of gut.

Step 4.—With a continuous catgut suture unite the corresponding edges of the openings in the two loops of gut (Fig. 549). This continuous suture involves all the coats of the intestine and shuts off the intestinal cavity from the line of Lembert sutures; at the same time it prevents loss of blood. The suture may be applied in the Connell fashion. v. Schmieden ("Zent. f. Chir.," April 15, 1911, No. 15,) advises using the old-fashioned postmortem suture for the anterior mucosa suture (Fig. 550). This inverts all the coats of the gut. Rovsing uses a similar stitch.

Step 5.—Continue the line of suture A, B (posterior row of Lembert suture) completely around the site of the anastomosis (Fig. 549, L, L, L), thus entirely burying from view the occlusion or hemostatic sutures introduced in Step 4. Fig. 551 shows the last of these sutures being introduced in the interrupted fashion. The continuous suture is as good as, or really better than, the interrupted.

FIG. 548.

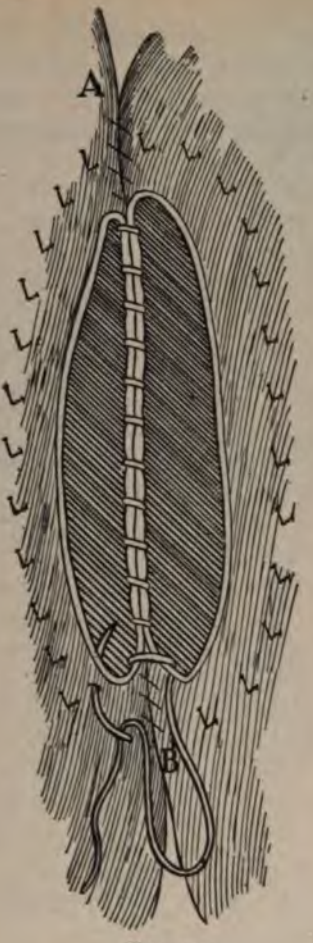


FIG. 549.

FIGS. 548 AND 549.—Abbé's operation.

FIG. 550.—(*Schmieden.*)

Step 6.—Review the line of suture and if necessary reinforce it by a extra stitches. Fig. 552 shows a sectional view of the anastomosis.

Step 7.—Remove the intestinal clamps. Clean the wound. Rem gauze pads. Return the intestines. Close the abdominal wound.

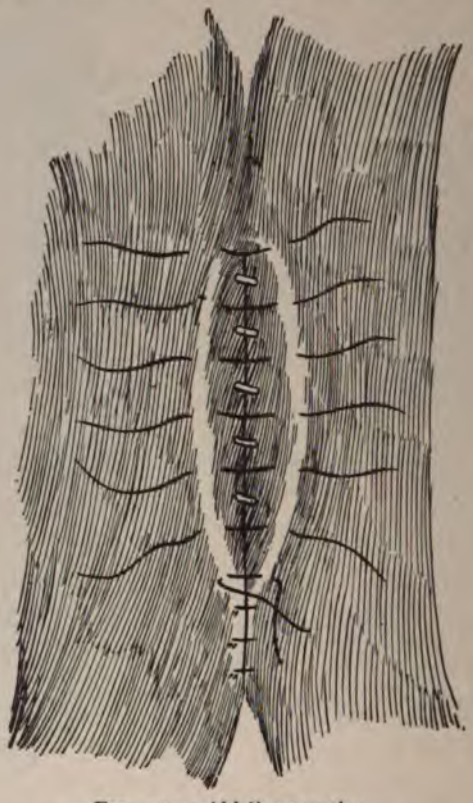


FIG. 551.—Abbé's operation.

Dr. Charles T. Parkes recommended a smaller opening in the gut that described above. After making a longitudinal incision through

FIG. 552.—Lateral anastomosis.

intestinal wall at a point *opposite* the mesenteric attachment, he made a s transverse incision at either end of it and so formed two flaps of gut which he turned inwards, fastening them in this position by a few sut

The turning-in of the flaps prevented contraction of the anastomotic openings. After making the openings in the opposing loops of gut, Parkes completed the union by a single row of continuous Lembert sutures, each stitch involving one-third inch of intestinal wall, the stitches being one-eighth of an inch apart.

"It makes no difference whatever what kind of suture is used, so that the principle of positively securing the application of two broad surfaces of peritoneum in contact with each other is certainly carried out." (Parkes.)

Fig. 553 shows how the Abbé operation may be more conveniently performed with the aid of two gastro-enterostomy clamps. The clamps used as in the diagram simplify the operation amazingly, hold the segments of gut in convenient position, prevent bleeding and prevent escape of intestinal contents.

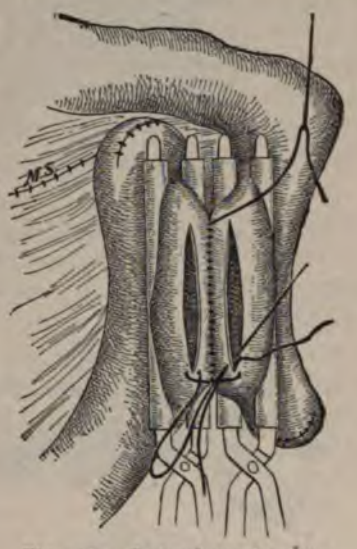


FIG. 553.—Lateral anastomosis.

Clamps in place. Posterior row serous sutures in place. Gut incised; through-and-through or Connell suture begun. When the through-and-through suture is in place completely around the anastomotic opening, remove the clamps and then insert the anterior row of serous sutures. In this diagram it is assumed that a portion of gut has been excised; that both afferent and efferent loops have been closed. M. S. indicates the line of union of the mesentery of the two loops of the gut. No holes must be left in the mesentery.

Lateral Anastomosis by Means of the Murphy Button.—*Step* 1.—Having opened the belly, pull the two loops of gut which it is desired to unite out from the abdominal cavity and protect the latter with gauze pads. Empty the segments of intestine and keep them empty by means of clamps.

Step 2.—Introduce a purse-string suture of fairly stout silk or catgut into the gut opposite its mesenteric attachment. The suture pierces all the coats of the gut. Make a longitudinal opening into the gut, large enough to permit the introduction of a Murphy button of appropriate size. This cut is in the area surrounded by the purse-string suture (Fig. 554).

Step 3.—Seize one-half of the Murphy button with hemostatic forceps and introduce its head into the gut. Weir has found that the forceps may so injure the button as to render it unsafe. Dawbarn plugs the two segments of the button with corks, thus providing handles and at the same time preventing escape of intestinal contents. Cordier has devised ingenious metal handles to plug the button and take the place of the corks.

Pull the purse-string tight and tie it in such a manner that the opening in the gut is snugly fastened around the neck of the button (Fig. 555). With scissors or knife remove any excess of tissue distal to the suture which might interfere with the proper approximation of the two halves of the button.

Repeat Steps 2 and 3 on the other loop of gut.

Step 4.—Remove the hemostatic forceps or corks from the two halves of the button. Insert the neck of the male half of the button into that of the female half and push them together firmly (Figs. 556 and 557). A few points of Lembert suture may be used to reinforce the union.

In Step 2 the incision may be made into the gut before the purse-str suture is introduced. A good method of applying the stitch is shown in Fig.

FIG. 554.

FIG. 555.

FIGS. 554 AND 555.—Use of Murphy's button. (*Monod and Vanverts.*)

FIG. 556.

FIG. 557.

FIGS. 556 AND 557.—Use of Murphy's button. (*Monod and Vanverts.*)

FIG. 558.—Use of Murphy's button.

Anastomosis by Means of McGraw's Elastic Ligature.—*Steps* 1 are identical with the operation by means of suture.

Step 3.—Thread a piece of well-rounded elastic-cord, about 3 diameter, in a straight Hagedorn needle. (The end of the cord is

with a knife to permit of threading.) Pass the needle into the lumen of the gut and out again at a point about 2½ inches distant. The track of the needle corresponds to the incision made into the gut in the suture operation. With a sharp jerk pull the needle and with it the elastic cord through the intestinal walls. The assistant keeps the cord on the stretch during this manœuvre. Repeat this in the opposite direction on the other loop of gut. Tighten the ligature as much as possible; cross its ends and secure them by a stout silk thread passed underneath and tied on top.

Step 4.—Complete the line of continuous Lembert suture around the site of anastomosis thus entirely hiding the elastic ligature. This finishes the intestinal part of the operation.

The elastic cord or ligature establishes a communication between the two loops of gut in from three to four days. By its use dangers of soiling the peritoneum by visceral contents escaping during the operation are eliminated. In the hands of McGraw, Willy Meyer, and others the method has proved very satisfactory.

End-to-end Anastomosis; Circular Enterorrhaphy.—In making an end-to-end anastomosis, whether by means of suture or the Murphy button, it is of prime importance to understand the anatomy of the mesenteric insertion. When the mesentery approaches the gut, its two peritoneal surfaces separate to surround the intestine and leave a Λ-shaped space loosely filled with fat and containing the vessels going to or from the gut. Opposite this space the muscular tunics lie uncovered by peritoneum. The most important stitch in circular enterorrhaphy is that which closes this space. The author has frequently operated with satisfaction in the following manner:

FIG. 559.

FIG. 560.

FIGS. 559 AND 560.—Circular enterorrhaphy.

Step 1.—Bring the divided ends of the two segments of gut together outside the belly cavity. Unite them by a stitch of silk or catgut at a point beside the mesenteric attachment, at a point on the free edge, and at a point midway between these two (Fig. 559). These three stitches insure uniformity in suturing. The same end may be attained by the use of miniature volsellae. With a continuous suture, involving all the coats of the gut, complete the union of the two segments (Fig. 560). This suture stops bleeding and prevents contamination of the next or essential row of sutures by the intestinal contents.

Step 2.—At the mesenteric attachment introduce a Mitchell-Hunner mesenteric mattress suture (Fig. 561), involving the serous, muscular, and submucous tunics. To secure serous apposition at the mesenteric space there is no suture comparable to the above. The suture shown in Fig. 562 is less desirable.

Step 3.—Introduce a Lembert suture at the free margin of the gut opposite the mesenteric attachment. Introduce a continuous Lembert suture all around the gut. Each stitch should pick up about ⅛ inch of the serous and subjacent muscular tunics. Do not pull the stitches very tight; all that is required is that serous coat should be kept in touch with serous coat (Fig. 563).

Step 4.—Review the wound. Where advisable reinforce the line of union with Lembert sutures. Beware, however, of causing too much invagination of the wound and thus producing stenosis.

FIG. 561.—Mitchell-Hunner stitch.

The late Dr. Chas. T. Parkes made use of the continuous Lembert suture in the manner described, but omitted the provisional suture which penetrates all the coats of the gut. Parkes writes, *apropos* of his experimental work: "The greatest number of mishaps followed drawing the sutures too tightly, which, if done, leads to death of the applied edges, and, of course, to failure They must be drawn only sufficiently close to bring the surfaces fairly in contact; the subsequent swelling from obstructed circulation will hold the sur-

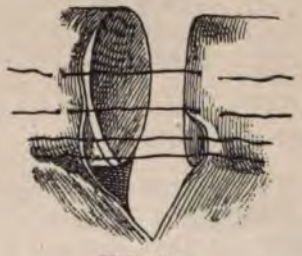


FIG. 562.

FIG. 563.

FIGS. 562 AND 563.—Circular enterorrhaphy.

faces firmly together until glued to each other by the rapidly forming adhesive material."

End-to-end anastomosis is most easily performed with the aid of clamps. Any good intestinal clamps, with rubber tubing over the blades, are suitable.

Step 1.—Clamp each of the segments of gut about one inch from their open ends. Place the clamps and contained gut side by side (Fig. 564).

Step 2.—Introduce the posterior row of continuous Lembert sutures (AB, Fig. 564).

Step 3.—Beginning at the mesenteric attachment, introduce a Connell suture (Figs. 564 and 565) completely around the gut, closing it entirely.

Step 4.—Complete the introduction of the continuous Lembert suture (AB, Fig. 566).

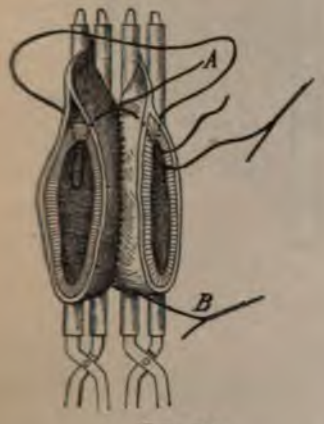


FIG. 564.

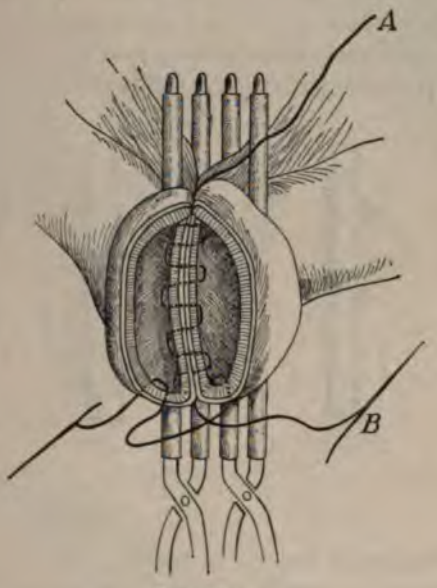


FIG. 565.

FIGS. 564 AND 565.—Connell's suture.

Step 5.—Close the rent in the mesentery.

Maunsell's Operation.—A portion of gut is supposed to have been excised.

Step 1.—Unite the severed ends of the gut by two sutures involving the whole thickness of the intestinal wall. One suture is inserted near the mesen-

FIG. 566.—Circular enterorrhaphy.

tery, the other on the opposite side of the intestine. The ends of both sutures are left long (Fig. 567).

Step 2.—On the free margin of the larger segment of gut (Fig. 567) make the longitudinal cut "*a*" at least one inch from the point of insertion of sutures.

Step 3.—With an eyed probe push the long sutures through the lumen of the gut and out of the cut "*a*." Pull upon the threads until the divided

ends of the gut emerge through the opening "*a*." Looking at the double tube of gut protruding through the opening "*a*" note that their peritoneal surfaces are in contact (Figs. 568 and 569).

Step 4.—Pass a straight, fine seamstress' needle through the protruded tube of gut and thus introduce about ten sutures of fine horse-hair or silkworm-gut. The sutures should be inserted about ¼ of an inch from the cut edge of gut. Pick up the sutures as they pass through the lumen of the gut and divide them, thus obtaining twenty sutures in position instead of ten. Tie the sutures.

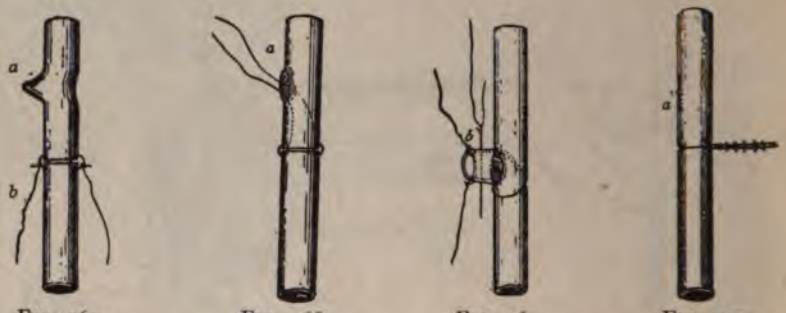


FIG. 567. FIG. 568. FIG. 569. FIG. 570.

FIGS. 567, 568, 569 AND 570.—Maunsell's operation. (*Maylard.*)

Iodoformize the line of stitches. Cut short the temporary stitches. Pull the protruded portion of bowel back into its normal position.

Step 5.—Close the wound "*a*" by appropriate sutures. Repair the mesentery (Fig. 570).

End-to-end Union by Means of the Murphy Button.—This operation is practically the same as that described for lateral anastomosis. The only point to be specially noticed is the method of closing the mesenteric space or insertion with the purse-string suture. Figs. 558, 571, 572, 573 explain themselves.

An endless number of contrivances—decalcified bone plates and bobbins, rawhide plates, catgut rings, segmented rubber rings, vegetable plates, etc.—have been invented to simplify intestinal anastomosis, but most have been discarded as cumbersome and unnecessary. The same may be said of numerous devices to support or distend the lumen of the gut while stitches are being inserted.

Of these, Harrington's segmented metal ring is probably by far the best. (See "Trans. Am. Surg. Assoc.," vol. xxii.)

The operation of lateral implantation, *i.e.*, where the end of one segment of gut is anastomosed to the side of another, is a combination of end-to-end and of lateral anastomoses, and is sufficiently explained by Figs. 574 and 575. Figs. 576 to 580 show a number of varieties of intestinal anastomosis and implantation.

Connell's method of enterorrhaphy is similar to Maunsell's in that the sutures penetrate the whole thickness of the gut-wall, and differs from it in the absence of the second incision into the gut.

FIG. 571.

FIG. 572.

FIG. 573.

FIGS. 571, 572 AND 573.—Use of Murphy's button. (*DaCosta.*)

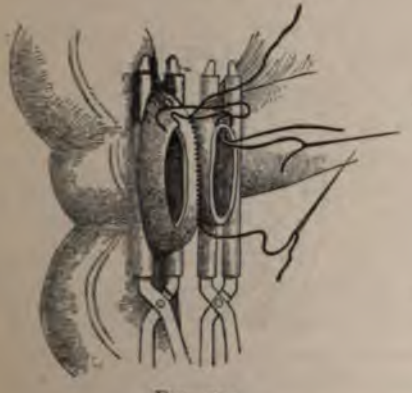


FIG. 574.

FIG. 575.

FIGS. 574 AND 575.—Lateral implantation.

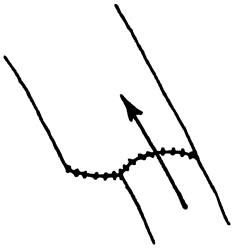


FIG. 576.

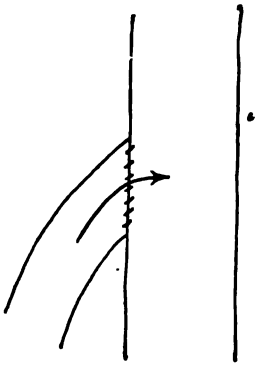


FIG. 577.

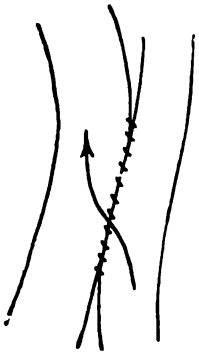


FIG. 578

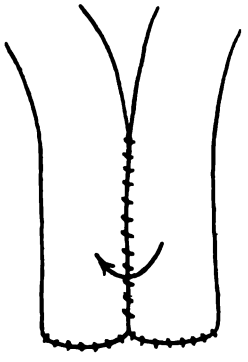


FIG. 579.

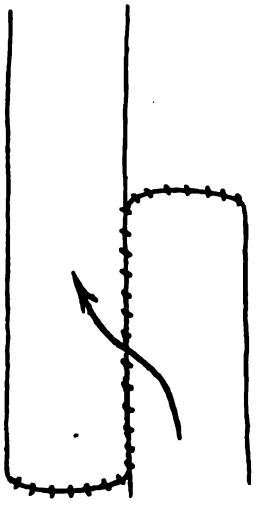


FIG. 580.

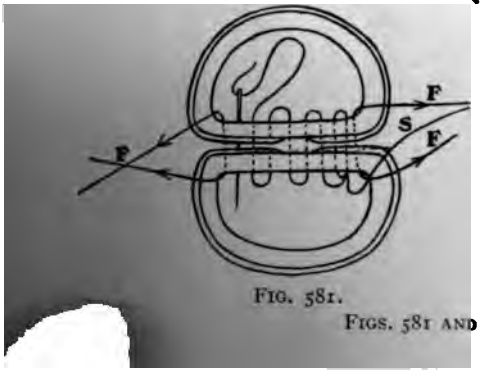


FIG. 581.

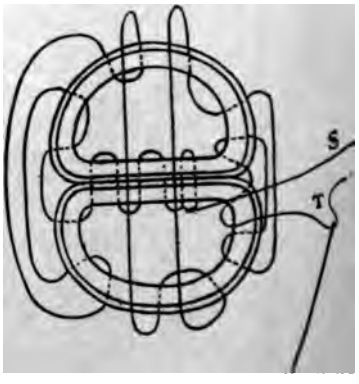


FIG. 582.

FIGS. 581 AND 582.—Connell's suture.

ɔ 1.—Place the ends of the gut in apposition, with the mesenteric attach-
ɔf one side corresponding to that of the other. Introduce two or more
n sutures, F (Fig. 581), to insure accuracy and uniformity in stitching.
d of fixation sutures, miniature volsellæ may be employed. Introduce
ɔntinuous suture (S) as shown in Fig. 581. In this manner fully two-
or even three-fourths of the circumference of the gut may be united.
emaining third or fourth of the wound is not so simply united, but if
;82 is carefully studied, the method will be clearly understood. When
ro portions of gut are united and the suture pulled sufficiently tight, the
ds of the suture T, S emerge at the same point (Fig. 583, x).

ɔ 2.—Introduce through the line of suture at the point Y (Fig. 583) a
d needle. Make the eye-end of the needle emerge alongside the sutures
S, at the point x. Pass the ends of T and S through the loop of the
n the needle and with the needle pull them out through the point Y.

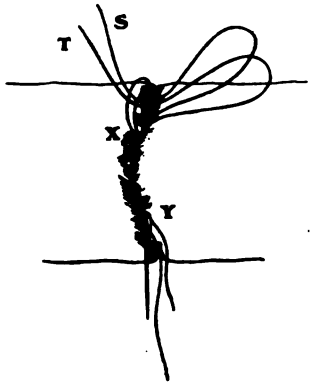


FIG. 583.

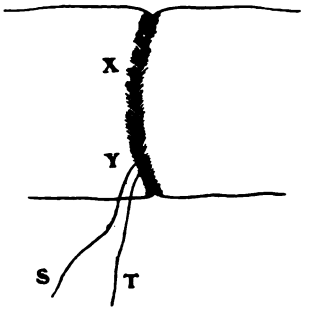


FIG. 584.

FIGS. 583 AND 584.—Connell's suture.

ɔ 3.—Slight traction on T and S will bring the mucous surface of the gut
point x into contact with the mucous surface at the point Y (Fig. 584).
the sutures T and S are tied tightly together and the knot allowed to slip
h the line of union at the point Y, this will sufficiently fasten the sutures.
tudent is strongly advised to familiarize himself thoroughly with this
d before attempting it on the living. An old coat makes a good model
ich to practise this operation. Imagine the wrist ends of the sleeves
pen ends of gut, and unite them. A few minutes of such practice with
e needle and thread makes easy the comprehension of this rather puzzling

marks on Anastomosis.—In the preceding pages many methods have
escribed by which union between various segments of the gastro-intestinal
may be effected for various purposes. The experienced surgeon has
iculty in making a selection of the method which will serve his purpose
hint suffices to equip him for the performance of some modified operation
e details of which he was not previously familiar. With the beginner
ative surgery it is entirely different. He ought to select a general method

of operating suitable for almost all cases, he ought to practise this method *nauseam* on intestines removed from hogs (vivisection is here unnecessa until he almost can carry out the minutest details with his eyes blindfold Having once established for himself a basal or normal method of operati excursions into the more refined elegancies of technic become easy and oft desirable.

Lateral anastomosis is the most universally applicable method of uniti one segment of gut to the other. It is the basal method of operating and mu be mastered in every detail by the surgeon before he presumes to open the a domen for any purpose, as in the course of the simplest of intra-abdomin operations circumstances may arise which compel interference with the i testinal canal.

The following operations are either identical or almost identical with later anastomosis:

A. *Gastro-gastrostomy in Hour-glass Stomach.*—(*a*) Union of the two stomac pouches by a moderate-sized opening. (Identical with lateral anastomosi (*b*) Union of the two pouches with restoration of the normal shape of t stomach. This procedure is practically the same as Finney's operatio (Almost identical with lateral anastomosis.)

B. *Finney's Operation.*—Gastro-duodenostomy. (Almost identical with la eral anastomosis.)

C. *Gastro-enterostomy.*—(Identical with lateral anastomosis.)

D. *Cholecystenterostomy.*—(Identical with lateral anastomosis.)

E. *Entero-enterostomy.*—Lateral anastomosis—indicated after excision of g (*e.g.*, in gangrenous hernia, tumor, et or for purposes of intestinal exclusion.

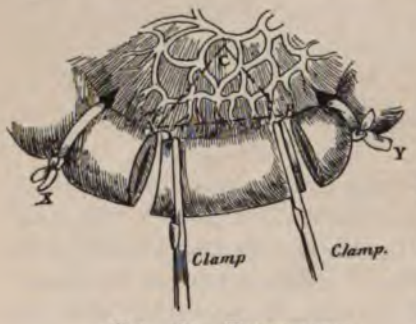


FIG. 585.—Enterectomy.

E. *Entero-colostomy.*—Lateral ana tomosis.

G. *Monari's uretero-ureterostomy* practically identical with later anastomosis.

Resection of a Portion of Sma Intestine.—The indications for th operation are localized malignant benign tumors; localized tuberculou lesions; gangrene; trauma extensiv enough to contraindicate local suturing, etc.

The Operation.—*Step* 1.—Open the belly in the middle line.

Step 2.—Pull the affected loop of gut outside the belly and protect th peritoneal cavity with gauze pads.

Step 3.—Empty the contents from the intestinal loop by "stripping" wit the fingers. Apply clamps.

Step 4.—Note the blood-supply as it passes through the mesentery. Ligat the vessels supplying the portion of gut to be removed.

Step 5.—Divide the intestine on each side of the disease at a point whe it is well supplied with blood (Fig. 585). Section of the gut should be mad obliquely, more of the free border being removed than of the mesenteric. Thi

is done: (*a*) because when obliquely divided the open ends of gut have a greater circumference than when cut transversely, and hence allow for the loss of diameter occasioned by suturing; (*b*) because the gut-wall on the non-attached border is more liable to be well nourished. If desirable, excise a V-shaped portion of mesentery corresponding to the segment of gut removed.

Step 6.—Either unite the ends of the gut by an end-to-end anastomosis or close them by means of suture, preferably purse-string, and provide for intestinal continuity by a lateral anastomosis.

Step 7.—If a V-shaped portion of mesentery has been removed, unite its edges by suture. If this has not been done, fold any redundancy upon itself and secure by a few stitches, being careful not to interfere with the nutrition of the gut. When several feet of intestine have been excised and especially when the mesentery is loaded with much fat it is impossible to suture the mesenteric wound neatly, leaving no raw surfaces. Even after much has been accomplished by suturing it is certain that a larger or smaller mass will protrude from the mesentery and if uncovered by peritoneum will invite adhesion and consequent ileus. When such a raw stump is present, choose a suitable portion of omentum; ligate and cut it off. Spread the omental sheet, thus obtained, over the raw stump and fix it by a few sutures.

Step 8.—Review the wound. Cleanse. Remove gauze pads. Return the gut into the belly. Close the abdomen.

Cæcectomy is indicated in cases of malignant or tuberculous disease, in some cases of intussusception, as well as in some cases of mobile or enlarged cæcum. Moynihan writes (Brit. Med. J., July 12, 1919):

"Many patients who suffer from vague dyspepsias, ascribed perhaps to intestinal stasis, or to chronic appendicitis, disclose on the operation table this condition: A membranous band, broad above, where it takes origin from the posterior abdominal wall, the under surface of the liver, the pelvis of the gall bladder, the cystic duct, and the duodenum, narrows below as it crosses the ascending colon to be lost on the peritoneum, to the inner side of the ascending colon, and on the enteric mesentery. Below this band, which is quite different from a "Jackson's membrane," the cæcum and the ascending colon are distended and soggy. Very often the appendix looks turgid, thick, and stiff. Removal of the appendix, to which the troubles are ascribed, gives little or no relief. Division of the band allows adhesions to re-form. The only practice likely to give good results is the removal of the terminal ileum, cæcum, and ascending colon. The performance of gastro-enterostomy, of course, makes matters worse."

Step 1.—Open the abdomen in right semilunar line; expose and examine the diseased organs.

Step 2.—Incise the posterior parietal peritoneum at the outer side of the cæcum and ascending colon. Free the cæcum from its bed by finger dissection. Ligate and divide the branches of the ileocolic artery to the necessary extent. Completely mobilize the diseased segment of gut. The cæcum may be so mobile, i.e., so well provided with mesocæcum, that ligatures or clamps may be applied directly without preliminary dissection.

Step 3.—Treat the mobilized gut as in Paul's colectomy or proceed as follows:

With two crushing forceps applied about 1 inch apart strongly clamp the ileum at a point 6 to 8 inches above the cæcum. Divide the gut between the forceps. Cleanse the cut surfaces.

Treatment of the proximal segment of the ileum: (*a*) With a continuous suture tightly close the open end of the gut (*i.e.*, distal to the clamp); (*b*) surround the gut about 1½ inches proximal to the clamp with a purse-string suture; (*c*) remove the clamp; invaginate the sutured end of the gut and tighten the purse string sutures.

FIG. 586.—Ileum anastomosed to ascending colon.
Peritonealization of wound. Divided ends of ileum and colon closed.

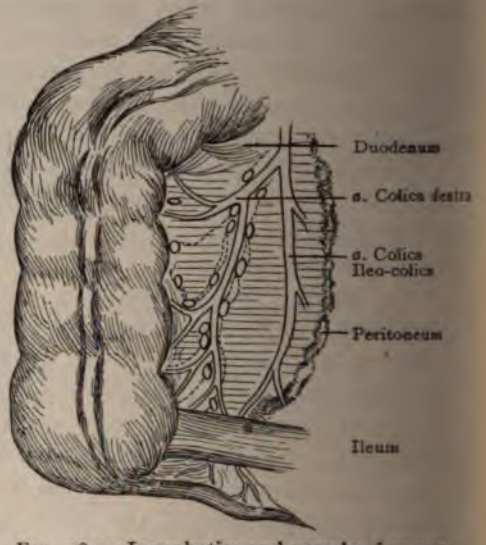


FIG. 587.—Lymphatics and vessels of cæcum.

In the same manner with crushing forceps doubly clamp and divide the ascending colon distal to the disease. Remove the diseased segment of gut. Treat this distal segment of colon in the same manner as the ileum.

Make a lateral anastomosis between the ileum and the colon or sigmoid, or, as is better, unite the end of the ileum to the side of the colon as described in the following paragraphs.

Repair the wound in the peritoneum (peritonealization) (Fig. 586). To do this it may be necessary to mobilize the parietal peritoneum on both sides of the raw surface left by the removal of the cæcum. Unless the peritoneum is mobilized and freed from the ureter when sutures are inserted and tied, the ureter may be kinked.

Jamison and Dobson ("Lancet," April 27, 1907) have made a very thorough study of the lymphatic system of the cæcum. The relation of the lymphatics training the cæcum and ascending colon to the ileo-colic vessels is shown in Fig. 587.

her method of operating is as follows:—

1.—Open the abdomen freely through the right rectus muscle. Apply dant protecting pack of gauze to the median side of the colon.

2.—Incise the parietal peritoneum along its line of reflection on to the ughout the whole length of the outer side of the ascending colon. By

-Mobilization of cæcum and ascending colon. Note duodenum and ureter exposed. (*Mayo.*)

id gauze dissection raise the cæcum and colon from their bed and con- e dissection inwards so as similarly to mobilize the ileo-colic vessels, phatic vessels and nodes along with the peritoneum covering them on ian side of the mobilized gut (Fig. 588). The ureter and part of the im are exposed by the dissection. If in case of carcinoma the ureter ed it may be removed and the kidney with it. Doubly ligate the ileo-

colic vessels high up. Similarly ligate them low down, not far from their junction with the superior mesenteric vessels supplying the terminal ileum.

Step 3.—Apply two crushing clamps to the ileum about three inches from the ileocecal valve and divide it between the clamps with the cautery.

Step 4.—From below up divide the mesentery of the cæcum and colon. Ligate and separate the omentum from the right one-third of the transverse colon. (If the operation is being performed for non-malignant disease it is unnecessary to remove so much mesentery or to excise the lymphatics.)

Step 5.—Divide the transverse colon with the cautery between crushing clamps. Remove the mobilized segment of bowel.

Step 6.—By stripping with the fingers push away the contents of the transverse colon for about four inches from the crushing clamp and apply an intestinal forceps there. Before removing the crushing clamps introduce a chromicized catgut suture as shown in Fig. 594 but do not yet tighten it. Remove the clamp and between the sutures pass the female (spring) part of a Murphy button into the bowel. Complete the suture of the end of the colon. Leave the ends of the suture long. Manipulate the button within the bowel so that its tube is pressed against one of the longitudinal muscular bands about 2½ inches from the end of the bowel. Make a crucial incision over the tube of the button just large enough to permit the tube to emerge and be tightly hugged by the gut walls. Secure the edge of the button with a hemostat. Similarly control the contents of the ileum by means of an intestinal clamp, remove the crushing clamp, surround the open end of the gut with purse-string suture, insert the other half of the Murphy button and secure it by the purse-string.

Push the two halves of the button together in the usual fashion, if necessary inserting a few supporting sutures. This gives an end to side anastomosis. Close the opening in the mesentery beside the anastomosis.

The Mayo's strongly recommend the "button" operation in this locality but the anastomosis can easily be made by sutures. A side to side anastomosis is often used but the blind ends may dilate and cause trouble as the author has found in at least one case.

Step 7.—By judicious suturing cover the raw surfaces with peritoneum.

Step 8.—Bring the blind end of the colon into but not through the muscular layer of the abdominal wound. Permit the long suture left attached to the colonic stump to emerge from the wound. Pack the wound down to the intestinal stump. Suture all the rest of the wound. If there is great distension of the blind end of the gut between the fourth and sixth days the gas may be let out by puncturing the gut under guidance of the suture. If there is no need of puncture the suture may be cut short, the small gauze pack removed and the wound permitted to heal.

Step 6 may be modified so as to secure an end-to-end anastomosis. A difficulty to be overcome is the smallness of the circumference of the ileum compared to that of the colon but a small longitudinal incision along the ileum on the side remote from the mesentery will so increase the extent of free edge that the end-to-end union becomes easy. Oblique section of the ileum fulfils the same purpose.

Partial Colectomy.*—The sigmoid or the transverse colon may be removed the same manner as described under the title "Enterectomy" except en the sigmoid is not sufficiently mobile. The ascending and descending rtions of the colon are usually well fixed to the parietes and require ecial treatment. Excision of the ascending colon is practically the same cæcectomy.

When colectomy is demanded because of practically complete obstruction ie to carcinoma, Desmarest urges a preliminary cæcostomy. The opening to the cæcum should be large so as to permit complete evacuation of the bowel ntents and frequent lavage for some days before the colectomy is attempted. he preliminary treatment has an added value in that it favors the dis- ppearance of œdema from the gut walls near the site of obstruction.

Under local anesthesia open the abdomen over the cæcum by the gridiron cision. The distended cæcum immediately pushes into the wound. Punc- re the cæcum with a small trocar to get rid of gas. Exteriorize a large cone cæcum and apply an intestinal clamp to the base of the cone. Proximal the clamp suture the bowel to the edges of the peritoneal wound. Place auze under the clamp to protect the wound. Open the gut widely and clean he mucosa with tincture of iodine. Suture the wound in the gut to the skin such a manner as to make the mucosa overlap the skin wound a little. Be articularly careful to accurately suture both angles of the wound. To do this, sert a 'U' suture through the angle of the wound in the gut and pass both nds of the suture from within out through the skin. As the intestinal clamp being removed tie the U suture.

Excision of Descending Colon.—*Step* 1.—Open the abdomen in the left emilunar line. Explore. Protect the rest of the abdomen with warm gauze ads. Desmarest (La Pr. Med. July 3, 1919) strongly recommends a ransverse incision on the left side above the umbilicus. This not only ives very free exposure but permits of convenient posterior drainage.

Step 2.—Incise the parietal peritoneum immediately external and parallel o the descending colon. This incision ought to extend well above and below he level of the disease in the colon. By blunt dissection with finger and gauze t is easy to raise not only the colon from its bed but the colonic vessels as well, long with the posterior parietal peritoneum, to the inner side of the colon. An rtificial mesocolon is thus formed containing the blood-vessels but only covered by peritoneum on one (the inner) side (see Cæcectomy). Be careful to avoid injuring the ureter. Continue mobilizing the colon (if necessary even its splenic flexure) until all the diseased segment can be delivered through the abdominal wound without tension. If care has been used in the blunt dis- section no harm has been inflicted on the blood-vessels. Bring the diseased segment of gut out through the abdominal wall.

Step 3.—Doubly ligate and divide the vessels going to the diseased segment of gut, thus leaving that segment completely free except for its continuation above and below. The ligation should be done high up on the vessels so that the lymphatic glands may be reached. The vessels may be tied either from

*For Transversectomy, see page 435.

behind after the gut has been mobilized or from in front as may be conv
Dissect all fat and lymphatic tissue from the site of ligation towards
along with those portions of the vessels attached to the gut. Ligation
vessels near their origin is most important, but it necessarily devitalizes
extent of bowel and all of the devitalized gut must of course be removed

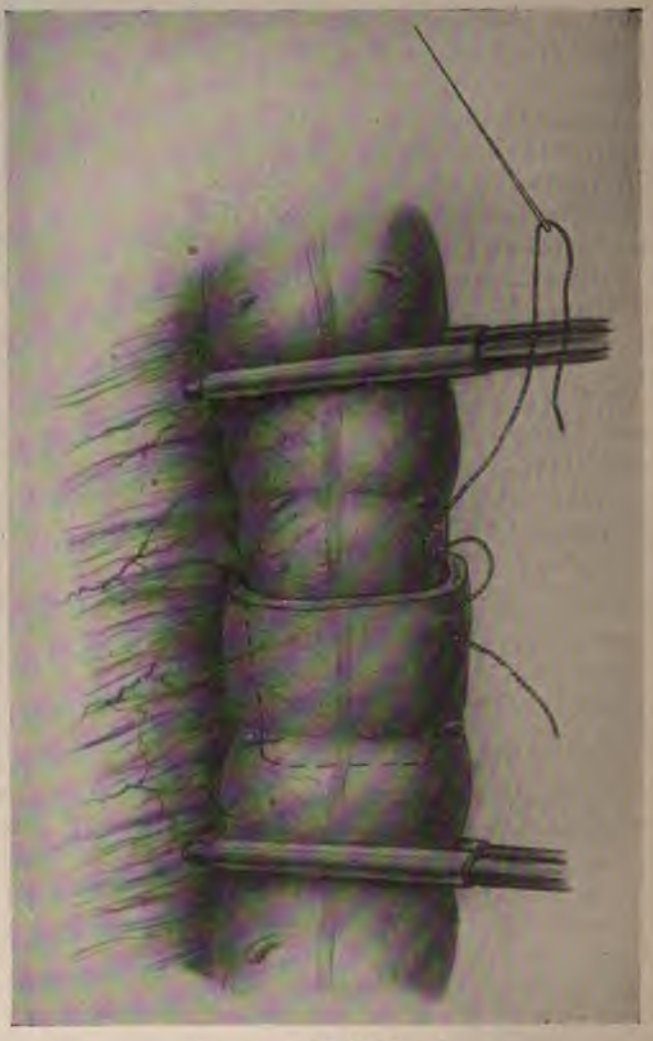


FIG. 589.—(*C. L. Gibson.*)

is really an advantage as ultimate success depends on thorough remo
the disease. Of course in non-malignant disease, *e.g.*, diverticulitis, su
tensive resection is entirely unnecessary.

Step 4.—At a safe distance above the disease and the devitalized
apply a crushing clamp to the gut, and an inch or an inch and one-half
up apply an intestinal clamp to the gut. Divide the gut between the
and sterilize the stumps with the cautery, carbolic acid or tincture of

ıply clamps (the crushing clamp nearer the diseased segment) below and divide the gut. Remove the diseased segment.

-Approximate the divided ends of the intestine. This is usually ıobilization has been sufficiently free. Moynihan urges that thorzation of the splenic flexure, without injury to its vascular supply, ɛssary to secure approximation of the intestine after resection.

ɨ.—Restore the continuity of the gut by means of Murphy's button ·dinary circular enterorrhaphy.

B.—C. L. Gibson's method ("Annals Surg.," July, 1910). Seize ıt edge of gut with two Kocher's forceps and push it into the lumen : end as far down as possible. Rotate "the upper segment about rcle so that the non-peritoneal surfaces do not entirely approximate ınference." Introduce a sufficient number of Lembert sutures as ig. 589. When tying the sutures tuck in or invaginate the upper lower segment as shown in Fig. 590.

FIG. 590.—(*C. L. Gibson.*)

·—The diseased segment of gut has been delivered and its vessels divided as in Step 3, but the gut has not been divided. Make stomosis between the afferent and efferent loops of gut. Doubly erent segments between the anastomosis and the disease. Divide veen the forceps. Close with sutures the open end of the gut ıstomosis; remove the clamp; invaginate the stump by means of ıg suture or a line of Lembert sutures. Do the same with the ›. Suture the two stumps to the parietal peritoneum.

Method D.—If it has been necessary to remove the splenic flexure along with the descending colon, close the open ends of the gut and make a lateral anastomosis between the transverse and the remnant of the descending colon or the sigmoid. If the whole colon and cæcum have been excised perform ileosigmoidostomy.

Method E.—Stephen Fenwick (Trans. R. Soc. Med. Surg. Sect., VII, No. 5) after excising a tumor of the sigmoid along with a V of mesentery found that an interval of about 3 inches existed between the segments of gut to be united, even after he had pulled the rectum up as far as possible. To fill the gap he selected a convenient loop of ileum about 5 inches in length, applied two intestinal clamps at each end of this loop, divided the gut between the clamps and carried the incisions up the meso-ileum between its vessels. He next united the proximal and distal segments of ileum by end-to-end anastomosis, and implanted the mobilized segment of gut, by means of two medium-sized Murphy buttons, to fill the defect in the sigmoid. The holes in the mesentery were carefully sutured. Recovery took place in spite of various complications. The bowel action was satisfactory and in three years there was no recurrence.

Step 6.—Repair the wound in the peritoneum. Close the abdomen.

Partial Colectomy in Two Stages.—*Steps* 1, 2, and 3 as in the preceding operation.

Step 4.—*Method A.*—Exactly as in Step 5, method C of preceding operation, make an anastomosis between the afferent and efferent loops of gut but do not yet excise the disease. Partially close the abdominal wound around the protruding intestine. Apply dressings.

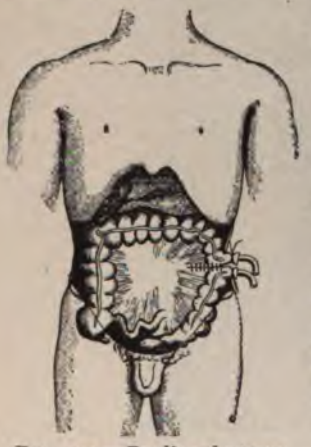


FIG. 591.—Paul's colectomy. (*Maylard.*)

Method B.—Deliver the diseased segment of gut. Unite with sutures the afferent to the efferent loops as they pass through the abdominal wall. Partially close the abdominal wound.

In both methods A and B the diseased segment of gut is excised after the lapse of from 12 to 48 hours. No anesthetic is usually necessary while removing the disease but bleeding is usually very free requiring many ligatures or sutures to be applied to the mucosa and submucosa. The result is of course a fecal fistula which may be closed later.

Method C.—(Paul's Colectomy.) Sew together the healthy segments of gut as they pass through the abdominal wound. Make an incision into the prolapsed gut above and below the disease. Into each intestinal opening pass a glass tube (Paul's, Mixter's) and ligate it there, Fig. 591. Cut away the diseased portion of gut. Partially close the wound. Apply dressings.

Complete Colectomy.—The transverse colon may be removed in the manner described under the title "Enterectomy," hemostasis being effected by a chain of ligatures applied to the transverse mesocolon and the great omentum between the stomach and colon. This method necessarily sacrifices the great omentum and leaves clumsy stumps which it is difficult to peritonealize satisfactorily.

vriter has found the following operation devised by Lardennois (Journ. June, 1914) to be unexpectedly easy while by it the omentum is :mostasis is simplified, clumsy stumps are avoided and if mobilization :patic and splenic flexures is necessary such is easily accomplished. 1.—After opening the abdomen and making a thorough exploration, great omentum and transverse colon out of the abdomen and reflect)wards. If *slight* traction is made upwards on the omentum nwards on the colon numerous delicate peritoneal folds will be

:.—Separation of omentum from transverse colon. (*Lardennois, Journ. de Chir.*)

sing from the omentum on to the colon (Fig. 592). Divide these folds carefully close to the gut and begin separating the omentum : colon with scissors, guided by the finger, introduced through nal cut. Often during this dissection the operator will think he has oled the omentum but usually his fears prove baseless but if this has occurred it is not of much importance unless a very large hole has 1. Continue the separation of the omentum upwards until not only 1 but the transverse mesocolon as well, lie free from the omentum

which is reflected upwards out of the way. When separation of the omentum from the colon is done to gain access to the lesser peritoneal cavity and to the posterior wall of the stomach the layer covering the transverse mesocolon is not elevated but is divided at or near its colonic attachment. Unless mobilization of the flexures is necessary or total colectomy is indicated proceed to Step 3.

Step 2.—Mobilization of the ascending and descending colon. Placing the finger flatly on the mesocolon burrow towards the left under the suspensory ligament of the splenic flexure and divide this avascular peritoneal band. This

FIG. 593.—(*Lardennois, Journ. de Chir.*)

detaches the splenic flexure more easily than is possible by any other me
Retract the descending colon upwards and continue the incision which mobil
the flexure, downwards through the parietal peritoneum close to its refle
on to the descending colon and with the finger separate the colon from its be
This mobilization of the descending colon and its vessels may be carried ou
freely even to a point not far from the middle line. In a similar manner th
hepatic flexure and the ascending colon may be mobilized, care being taken to
avoid injuring the ureter.

Step 3.—Return the great omentum into the abdomen. Lift the colon nto the air so as to spread out its meson and make its blood-vessels clearly visible. If the transverse colon alone is to be excised, doubly clamp the vessels passing to that part of the gut, divide the meson between the clamps, excise the desired portion of intestine and restore intestinal continuity by a lateral or preferably, an end-to-end anastomosis. If a more complete colectomy is necessary it is easy to assure exact hemostasis by applying ligatures to the middle and right colic arteries near their origin, and to the left colic vessels at such points as will not endanger the vitality of the gut which is to be retained. Divide the mesocolon along the line shown in Fig. 593.

Step 4.—The whole colon is now free except for its continuation into the cæcum and sigmoid.

Place the patient in Trendelenburg's position so that the small intestines can be kept out of the way.

Choose the point of section on the pelvic colon. Crush the gut with forceps (Doyen's; Payr's) and apply a silk ligature tightly in the groove left by the forceps. Apply a strong clamp to the gut a little above the ligature. Divide the gut with a cautery between the ligature and the clamp and place the clamped (upper) end of the gut away from the field of operation. Insert a purse-string suture around the distal (ligated) segment of gut and invert the stump. Instead of removing the Payr's clamp one may cut between it and the clamp on the upper segment of gut, with a cautery, being careful to destroy all the tissue between the two clamps and to thoroughly sear or desiccate the tissues crushed between the blades of the Payr's clamp (distal segment of gut). Keeping the clamp *in situ* insert a continuous suture, the alternate stitches being on opposite sides of the clamp (Fig. 594) and the loops of the thread passing over the clamp. Remove the clamp. The crushed and burned edges of the wound adhere together so that there is no danger of the lumen of the gut opening or of bleeding occurring. Traction on the two ends of the silk suture causes a neat and thorough invertion of the wound. Fix the ends of the suture and insert a second row of sutures.

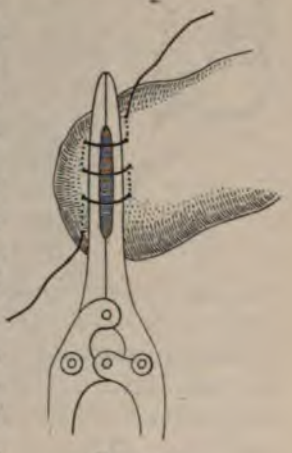


FIG. 594.

Step 5.—Mobilize the cæcum and lower end of the ileum as in cæcectomy. Ligate the ileocolic artery at an appropriate point. Choose the site for dividing the ileum. Immediately distal to this site apply a crushing forceps (Ochsner's forceps) to the ileum. Above this line of section apply a reliable intestinal forceps. Divide the gut close to the crushing forceps. This completes the excision of the colon.

Step 6.—Implant the end of the ileum into the side of the pelvic colon.

Step 7.—Review the wound left by the removal of the colon and cover all raw surfaces with peritoneum.

Lane at this stage of the operation has an assistant pass a rubber tube through the anus and the surgeon guides it through the anastomotic opening.

Such direct drainage of the small intestine for a few days is distinctly valuable.

Subcæcal Colectomy.—If it is justifiable to preserve the cæcum when a colectomy is indicated Lardennois thinks it is very advantageous to do so, as one then saves the very active terminal ileum, the ileocæcal valve and the cæcum itself where valuable digestive processes take place.

The Operation.—Mobilize the colon and divide its mesenteries as in total colectomy but do not yet interfere with the cæcum. Choose the site of section in the ascending colon. Apply a crushing clamp (Payr's) to the cæcal side of the line of section and a strong Ochsner's clamp to the distal side. Divide between the clamps with a cautery. Lay aside (well protected) the clamped distal segment of gut. Apply a continuous silk or chromicized catgut suture to the clamped cæcum by means of which the wound is closed and inverted when the clamp is removed exactly as the pelvic colon was treated in complete colectomy. Choose a portion of the sigmoid which can be brought without tension into apposition with the blind fundus of the cæcum. At this site apply two clamps to the sigmoid (a crushing clamp above, an intestinal clamp below) and divide the gut between these clamps. The resected portion of the colon is now removed. Apply an intestinal clamp to the fundus of the cæcum. Anastomose the end of the sigmoid to the fundus of the cæcum, Fig. 595. The appendix ought, of course, to be removed. Obliterate all openings through which a loop of small intestine might penetrate and give rise to obstruction.

FIG. 595.

Lane's Colectomy.—Lane in performing colectomy makes no endeavor to save the omentum. After opening the abdomen his first endeavor is to separate the "evolutionary adhesions" from the mesenteries without injury to the latter structures. This greatly facilitates the removal of the bowel and as little or none of the mesentery is denuded of its peritoneal covering the risk of dangerous adhesions to the small intestine is lessened. In ligating the vessels no large masses of mesentery should be included. "It is well to remember that one of the chief immediate risks of the operation is hemorrhage, which may result either from the escape of a vessel from the ligature in a fat subject, or from the friability of the ligatured vessels in a thin toxic one." The ileum is divided as in ileo-colostomy. The pelvic colon is drawn up out of the pelvis and grasped with two pairs of forceps (Ochsner's) about 2 inches above the pelvic brim. The end of the ileum is attached directly to the cut end of the pelvic colon by the usual method of end-to-end anastomosis. When the circumference of the colon is considerably greater than that of the ileum if the stitches in the wider gut are inserted more widely apart than in the narrower gut then a secure union is easily obtained.

The cut edges of the ileal and colonic mesenteries must be carefully united by suturing both the upper and lower aspects of their junction. Lane finds the end-to-end anastomosis preferable in every respect to the lateral or end-to-side.

In the treatment of intestinal stasis Lane considers colectomy the opera-

choice. He also prefers it to any partial operation in obstruction due obile colonic tumors and in megalo-colon.

Cæcopexy.—Wilms' Method. *Step* 1.—Open the abdomen by a right rec- incision. As a matter of routine remove the appendix. Select a site in iliac fossa against which the cæcum can be placed without the production ny kinking in the colon or ileum.

Step 2.—Reflect a flap of peritoneum from the iliac fossa. Place the caput on the raw surface thus prepared and suture the peritoneal flap over the m, Fig. 596.

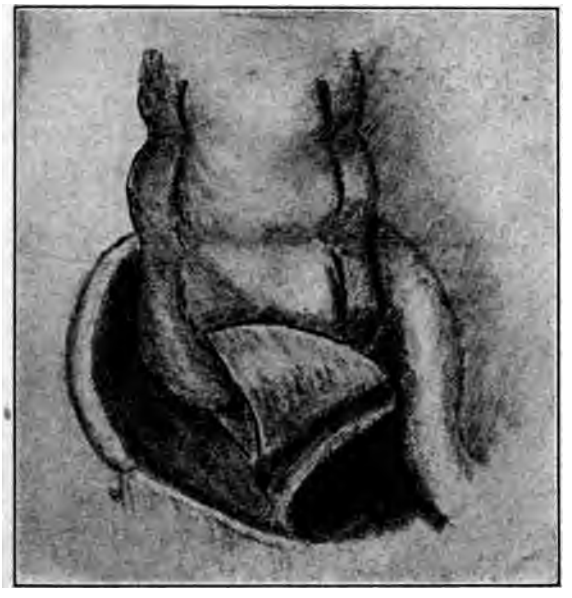


FIG. 596.—Cæcopexy.

ep 3.—Close the abdomen.

uenu and Duval's Method (Rev. de Chir., May 10, 1914).—Place the pa- in Trendelenburg's position. Open the abdomen in the ileo-cæcal region. nine the cæcum. If the mobile cæcum is too long or dilated, lessen its by transverse or longitudinal plication or by both. Introduce a retractor expose the whole iliac fossa. Recognize the right iliac artery and make an ion through the iliac peritoneum external and parallel to the vessel. This xtends from the middle of the iliac fossa to the posterior point of fixation e cæcum in the lumbar region. If the colon is now slightly freed from its by dissection it is advantageous. Through the peritoneal incision expose endon of the psoas parvus muscle, or if this is absent, the internal border e psoas, in which case it is necessary to retract the artery inwards to per- suturing. Introduce three or four non-absorbable sutures through the n of the psoas parvus and then through the posterior longitudinal cæco- band. When these sutures are tied the cæcum is well anchored in the

iliac fossa. Suture the edges of the incision in the iliac peritoneum to the head of the cæcum.

Cæcopexy plus Cæcoplication.—Roeder ("Journ. A. M. A.," Feb. 25, 1911) introduces a number of sutures (hemp or silk) into the outer side of the cæcum in the manner shown in Fig. 597. The last bite of the stitch is in the parietal peritoneum just external to the root of the meso-cæcum. The number of bites each stitch takes in the gut is regulated by the amount of dilatation present. The number of stitches used is of course in proportion to the length of intestine to be plicated and anchored.

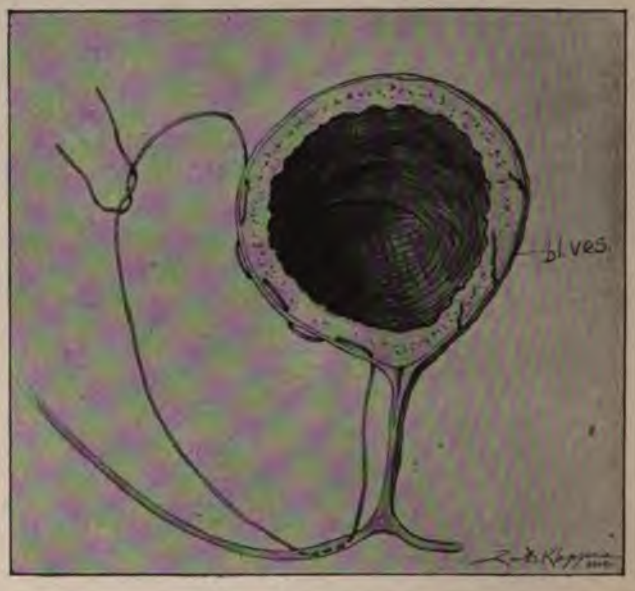


FIG. 597.—(*Roeder.*)

DIVERTICULITIS

The papers of Cahier ("Rev. de Chir.," September 19, 1906), Brewer ("Amer. Journ. Med. Sc.," October, 1907), Mayo ("Surg., Gyn. and Obstetrics," July, 1907) and others have attracted attention to a condition named acquired diverticulitis. A few words explanatory of the disease may assist the operator. Acquired or false diverticula are simple herniæ of the mucous and submucous tunics through the circular muscular coat of the descending colon and sigmoid at points where the musculosa happens to be weak. Chronic leakage may take place through the diverticular walls and give rise to large inflammatory deposits. The result of the inflammation may be: (1) Abscess. This requires free drainage. (2) Acute local infection *plus* acute obstruction. This requires free drainage *plus* the establishment of an artificial anus. Subsequently, if necessary, the diseased segment of colon may be excised. (3) Chronic obstruction with inflammatory tumor but no abscess. This form is usually

staken for malignant disease. The treatment is resection of the involved gment of gut.

Hirschsprung's Disease. (Megalo-colon. Congenital dilatation of colon.) his disease generally but by no means always occurs in young children, is aracterized by inveterate constipation, the dilated colon being loaded with ard fæces. The use of purgatives and lavage may give temporary relief, but ooner or later colitis shows itself by the symptom of diarrhea alternating with onstipation. The mortality in cases treated medically has been reported as 4 per cent. and 66 per cent. in different series, while in those treated surgically has been 48, 34 and 25 per cent.

Plastic operations and suspension of the colon have not been useful. Appendicostomy and colostomy have been useful as temporary measures. The deal treatment seems to be excision of the whole affected segment of intestine. As a preliminary to colectomy it is often wise to divide the ileum near its termination and to unite its end to the lowest possible point in the rectum. (End-to-side anastomosis.) In children the open pelvis makes the low anastomosis easier than in adults. Later the colon may be removed. After recovery care should be exercised to prevent any accumulation of scybalæ in the rectal pouch.

Finney's article on Hirschsprung's Disease (Trans. Am. Surg. Assoc., 1908, vol. XXV, 475, or Surg., Gyn. and Obst., VI, 6) gives a very full bibliography. See also W. I. Terry (Journ. A. M. A., LVII, 731) and Barrington-Ward (Brit. Jour. of Surg., I, 345).

INTESTINAL EXCLUSION OR SEGREGATION

Exclusion or Segregation of Intestine.—In some cases where, from extensive adhesions or from other causes, it seems impossible or improper to excise a certain segment of gut, good results may be obtained by protecting it from the irritations incident to the performance of its physiological functions. In this way fæcal fistulæ may be induced to close and some neoplasms may develop less rapidly. The operation which is used for this purpose may be named "*exclusion of the intestine.*" Tuberculous lesions of the intestine, unless fairly easy of excision, may well be treated by exclusion.

Ileo-colostomy.—Ileo-sigmoidostomy.—Lane's Method.—*Step* 1.—During the administration of the anesthetic begin the hypodermic administration of salt solution in both axillæ and keep it up during the operation. Six or more pints may be given.

Step 2.—Open the abdomen by a suitable vertical incision to the left of the middle line so as to divide the sheath of the rectus twice and thus obtain a secure abdominal scar.

Step 3.—Pick up the ileum and apply two Ochsner (crushing) clamps to it, close together, about 6 inches from its termination. Divide the gut between the forceps by means of a cautery thus completely sterilizing the stumps of the gut. Close the distal aperture by means of a running suture applied before and tightened during removal of the clamp. Invaginate the closed stump by means of a purse-string suture exactly as an appendix stump is invaginated.

Step 4.—At a convenient distance from the crushing clamp apply an intestinal clamp to the proximal segment of ileum and anastomose its end to the side of the upper part of the pelvic colon using the usual two rows of suture. Should the junction appear insecure at any point, owing to tenuity of the ileal wall, to inflammatory changes in the pelvic colon or to the abundant deposit of fat in the colonic peritoneum, reinforce with extra stitches.

Step 5.—Draw the intestines out of the pelvis. Very carefully sew the adjacent surface of the pelvic colon to the divided margin of the mesentery of the ileum. This is so important that it is wise to suture not merely the upper but also the lower aspect of the junction, otherwise internal hernia may result or the constant pressure of the small intestines may cause separation of the mesenteries and lead to trouble or disaster.

Step 6.—Examine the fixation of the sigmoid to the pelvis. If what Lane calls the "last kink" is tightly fixed at the brim of the pelvis nothing need be done to it; but if it is not so fixed, sew the bowel and mesentery very securely to the brim so as to reduce the tendency to the regurgitation of fæces up into the iliac colon.

Step 7.—Have an assistant pass an œsophageal tube through the anus into the pelvic colon and guided by the fingers of the surgeon, through the anastomosis into the ileum for a distance of about 8 inches. (The tube should be secured to the anus by a stitch.) "If any difficulty is experienced in passing the tube, a quantity of paraffin is injected through it which materially facilitates its introduction. This tube prevents the accumulation of gas in the small intestines, and permits of the free passage of the fluid contents through the junction, and their collection in a vessel beneath the bed."

Step 8.—Introduce two or more pints of warm saline solution into the peritoneal cavity in an endeavor to prevent the formation of adhesions (to reduce this risk still further the patient is moved from side to side at frequent intervals during the after-treatment). Close the abdominal wound.

In the treatment of "Intestinal Stasis" Lane recommends ileo-colostomy highly when the preferable operation of colectomy seems too dangerous. When colectomy is proper its immediate risk is less than that of ileo-colostomy and the convalescence is much less stormy.

In the belief that chronic intestinal stasis is *the* predisposing cause of tuberculosis of the bones and joints, Lane begins treatment of these lesions by performing ileo-colostomy.

An operation along the lines of ileo-sigmoidostomy has often been used in the treatment of idiopathic dilatation of the colon (Hirschsprung's disease). It must be remembered, however, that the hugely distended sigmoid colon may subsequently give rise to volvulus. In at least one case, even after much of the sigmoid was excised for volvulus, the remnant of sigmoid between the anastomosis and the rectum became hugely dilated and once more occasioned volvulus. Mr. Makins corrected the position of the loop and fixed it with good effect (Hawkins, "Brit. Med. Journ.," March 2, 1907).

Yeomans ("Am. Journ. of Surg.," Jan., 1913) recommends cæco-sigmoidostomy instead of ileo-sigmoidostomy in suitable cases as by it a more thorough drainage of the segregated or excluded colon can be obtained.

-sigmoidostomy.—Typhlo-sigmoidostomy.—Put the patient in the
nburg position.
the abdomen by a free median, rectus or transverse incision. Explore
men.
the small intestines out of the way and protect them with moist

e cæcum and sigmoid are easily apposed proceed with the operation.
bility of the cæcum impedes approximation, mobilize it by incising the

FIG. 598.—(*Lardennois and Okinczyc, Journ. de Chir.*)

peritoneum along its outer and lower border and raising it as in cæcec-
Beware of injuring the ureter. If the sigmoid is immobile divide the
um forming the external or inferior layer of its meson and mobilize
y as the descending colon is mobilized in colectomy but carefully avoid
the vessels.
a fine curved needle introduce the suture shown in Fig. 598 (Larden-
Okinczyc, Journ. de Chir., May, 1913, p. 542). This stitch involves
r or inner layer of the meso-sigmoid, the median parietal peritoneum and
he undersurface of the meso-ileum. It is easy to avoid injury to vessels

if one picks up the parietal peritoneum with forceps before introducing the needle at any point. Apply a hemostat to each end of the stitch and put it aside.

Remove the appendix. Make an anastomosis between the blind end of the cæcum and a convenient part of the sigmoid. When the anastomosis is complete tighten and tie the suture A B, and so prevent the possibility of a peritoneal lacuna being formed behind the anastomosis with its dangers of internal hernia.

Some surgeons *complicate* the operation as follows: Choose a portion of the pelvic colon as low down as practicable and there divide the gut between intestinal forceps. Anastomose the open end of the proximal loop of colon to the side of the distal segment. Anastomose the open end of the distal segment to the blind end of the cæcum.

FIG. 599.—Unilateral exclusion.

In the following description it is assumed that the cæcum and adjacent segment of ileum are diseased and require to be segregated.

(A) *Unilateral Exclusion.*—*Step* 1.—Open the abdomen in a suitable position. Examine the diseased structures.

Step 2.—Find, empty, and doubly clamp the afferent segment of gut, *i.e.*, the portion of healthy gut which passes into the diseased segment. Divide the gut between the clamps. Close each end of the gut by a row of through-and-through sutures covered by a row of continuous Lembert sutures. (Fig. 599, X, Y).* If desired, the purse-string suture may be employed.

Step 3.—Make an anastomosis between the afferent loop of gut and the colon in a suitable place (Fig. 599, A).

Step 4.—Close the abdomen.

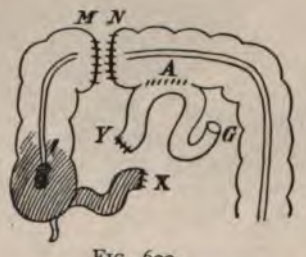


FIG. 600.

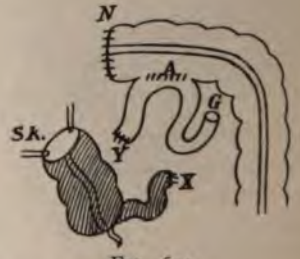


FIG. 601.

FIGS. 600 AND 601.—Bilateral exclusion with drainage.

The effect of unilateral exclusion is that while the contents of the excluded segment drain into the colon, no material from the ileum passes into it—in fact, a short circuit is established.

(B) *Bilateral Exclusion.*—This method is proper only when a fistula leads from the skin into the segment to be excluded. The only difference between the bilateral and the unilateral operation consists in the division and suture of the colon distal to the disease and proximal to the anastomosis (Fig. 600).

* Rutherford Morison has shown that if the cæcum is excluded by division of the ascending colon and mere anastomosis of the ileum (without complete division of the ileum) to the colon, then the cæcum will burst unless the ileocæcal valve happens to be incompetent. This error seems to the author so bad that the warning ought to be unnecessary *but* the accident has happened.

C) *Bilateral Exclusion with Drainage of the Excluded Segment.*—Here no
la leads into the diseased segment. The operation is identical with that
lateral exclusion up to the point where the colon is divided. Now, instead
osing both ends of the colon at the point of section, only the distal segment
osed (Fig. 601, N), while the open end of the diseased segment is united
ıe skin and permits drainage (Sk.).

Vautrin thinks and has proved that drainage from one end of the excluded
ıent of gut is only sufficient if the disease is of comparatively limited extent.
ıre the disease is extensive and the gut to be drained is more or less coiled,
ı both ends of the segregated segment should be united to the skin at con-
ent points; if necessary, special openings being made through the belly-
. This permits of thorough drainage and lavage, whereby the diseased
lumen may be kept clean and ulcerations may receive local treatment.

INTESTINAL OBSTRUCTION

Whichever form of obstruction is present and demands operation, there are
ain points common to the treatment of all of them, and which will be con-
ıed here.

Before assuming that true obstruction is present it is of vast moment to
mine the urine. In the opinion of Paul Delbet ("La Presse Med.," Aug. 24,
7) the possible existence of constipation in the course of uremia is most
ortant because if one considers that uremia may long remain latent; that
ıay provoke as its first symptoms, gastric intolerance with vomiting first
ıentary then bilious; that there may be subnormal temperature and a
kening of pulse, one can understand that constipation accompanied by
ıe symptoms may give the appearance of true intestinal obstruction to a
ıplaint which is entirely non-surgical.

As a matter of routine, the rectum must be explored; the omission to do this
too often led the surgeon to operate unnecessarily or to miss the aid of valu-
information when operating.* There is often not much time in which to
pare the patient. Enemata will almost certainly have been used before the
stion of operating has been decided, and hence the lower gut is empty. It
ıse to clean out the stomach with the stomach-tube. When there are great
vousness and depression, a small dose of morphine has a quieting and steady-
effect which outweighs any ill which it may do. Usually the abdomen
ıpened in the middle line below the umbilicus. Through this opening any
truction may be reached and treated.

How to Find the Point of Obstruction.—Theoretically one might proceed,
ıs usually advised, in the following methodical manner: Pass the finger or
ıd into the right iliac region and palpate the cæcum. If the cæcum is dis-
ded, pass the hand along the colon, as the obstruction must be lower down.
ıe cæcum is not distended, the obstruction must be in the small intestine.
d a segment of gut which is not distended. Trace the mesentery of the

Mackenzie ("Brit. Med. Journ.," June 20, 1906) maintains that violent pain (peris-
) across the middle of the abdomen, *not* below the umbilicus, signifies that the site of the
truction is in the small intestine while hypogastric pain means that it is in some part of the
intestine

loop of gut under examination to its origin from the spine and find which is its upper surface. Remember that the right layer of the mesentery is also its upper layer. Having found the upper or right surface of the mesentery, that portion of gut which goes to the left is the upper segment, and if followed will assuredly lead to the point of obstruction. Trace the gut up to the point of obstruction, but do *not* let the intestines come out of the belly cavity.

But the belly-walls are generally tense, the intestines are ballooned with gas, the transverse colon is pushed up under the diaphragm, and to carry out the methodical examination described would be very hazardous, even if possible. Greig Smith gave excellent advice as to finding the obstruction. He noted that wherever the obstruction is located it is probable that the most dilated coils will rise to the surface; and, the greater amount of bowel being within three inches of the umbilicus, it is probable that the most dilated coils will be within sight. Very gently move the coils from side to side and up and down, and fix on the most dilated coil, which will be at the same time the most congested. Follow this coil in the direction of increasing distention and congestion. "It will certainly lead to the stricture. The whole manipulation may be carried out with two fingers." If this method fail, Greig Smith recommended to let the most distended coil escape from the belly, protected by a large pad. One end of the coil escapes less readily that the other and appears more congested; this end of the coil will lead to the obstruction.

When the intestines are very much distended with gas, there are certain dangers to be feared and combated during the operation:

1. During the necessary manipulations the pressure of the fingers or hand may cause rupture of the gut.

2. If rupture is avoided and the direct cause of obstruction relieved, the ballooning of the gut may cause kinking or valve formation of individual loops and so prevent emptying of the bowel.

3. Prolonged overdistention so paralyzes or weakens the intestinal muscles that they are unable to contract.

4. The operation being completed, it may be impossible to close the abdominal wound over the dilated intestines.

Greig Smith held that "no operation for intestinal obstruction is properly completed if the patient leaves the operating-table with a greatly distended abdomen."

Dahlgren ("Centralblatt f. Chir.," April 15, 1905), after incising the intestine, "milks" it throughout its whole length, using gloved hands or a special instrument consisting of two cylinders like bobbins held together by a spring. This he finds specially useful in general peritonitis with intestinal paralysis. In ileus without mechanical obstruction he finds atropin sulphate hypodermically, 1 milligramme repeated, of great value. He began using the atropin without faith as a last resort, but has learned its value (has given 5 to 7 milligrammes in twelve to fifteen hours). Pituitrin is of great value.

After the direct cause of the obstruction has been located and treated, or, if more convenient, before that is done, permit one of the most distended loops of gut to protrude from the belly. Protect the abdominal cavity with hot pads or soft towels. Make an incision into the gut (either transverse or longitudinal)

d encourage its contents to escape into a suitable vessel. When the con-
ıts cease to escape, clean the wound and close it with a continuous Lembert
ure. If necessary, repeat this procedure on other distended loops.* A prac-
al detail which may be of value in carrying out the above is to have a com-
tent assistant assigned to incise, clean and close the gut, and that for his work
should be provided with instruments, sutures, and sponges entirely separate
ım those used by the operator. The object of this detail is, of course, that
e operator and his first assistant may avoid soiling their hands. The use
rubber gloves which can be changed is of much value.

Before closing the last of the enterotomy wounds one may, through it, in-
ɔduce into the gut an ounce of sulphate of magnesia in solution, or one may
ject the solution into the gut by means of a syringe with a suitable cannula,
bsequently closing the puncture with one or more stitches.

When operating for ileus particularly following pelvic inflammations and
pendicitis, an obstruction is often found affecting the ileum not very far
ɔm the ileo-cæcal junction. After removing this obstruction it is well to
amine the sigmoid or pelvic colon as not infrequently there is also an ob-
ruction present where that gut passes the brim of the pelvis (Ileus Duplex,
ımpson Handley, Lancet, May 1, 1915).

If the patient is very much collapsed or if it is difficult to find and treat the
rect cause of the obstruction, the surgeon should throw aside all ambition to
) a complete operation and content himself with bringing the most distended
il of intestine into the abdominal wound and fixing and opening it there
nterostomy). If the patient's strength is equal to the strain, it may be well
) precede the enterostomy by evacuating the gut at several places in the man-
r already described, as the intestine may refuse to empty itself through one
ɔening.

Very many lives have been saved by means of enterostomy which would
ıve been sacrificed had a more complete operation been attempted. When
fficient strength has been gained, the patient must be submitted to a second
d radical operation. It must be remembered that death from obstruction is
actically always due to intestinal intoxication. Clairmont and Ranzi found
at while the filtrate from the contents of the normal intestine produced no
rmful effects when injected into animals, a similar filtrate prepared from the
ntents of a loop of strangulated bowel produced serious and often fatal results
ıen injected. When obstruction of the large intestine below the cæcum is
mplete, by far the best results are to be obtained from the formation of an
tificial anus which may be closed later. When the obstruction is actually at
e ileo-cæcal valve and it is necessary to open the small bowel, Paul prefers an
ıastomosis because "there are such decided objections to a fæcal fistula con-
ɛcted with the small intestine, and usually such favorable prospects for short
rcuiting in this situation, that the additional immediate risk may be accepted
ıless paresis and collapse have already supervened, when an artificial anus is
perative."

If the complete obstruction is known to be in the large intestine distal to the

*This evacuation is by no means always required. It should be done only if distension is great that the gut will probably be unable to empty itself in the natural manner.

cæcum and is not due to a twist in the sigmoid then a simple right la colostomy is the operation of choice. The artificial anus is only intended temporary and its posterior position is out of the way when laparotomy is formed later to treat directly the lesion causing the obstruction (Paul "Med. Journ.," July 27, 1912).

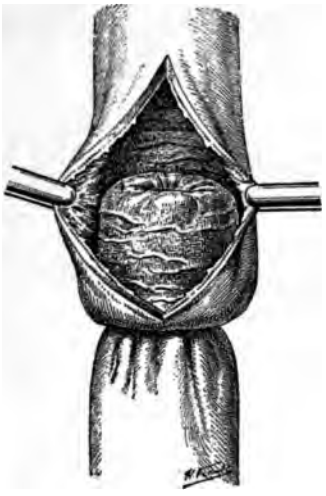


FIG. 602.

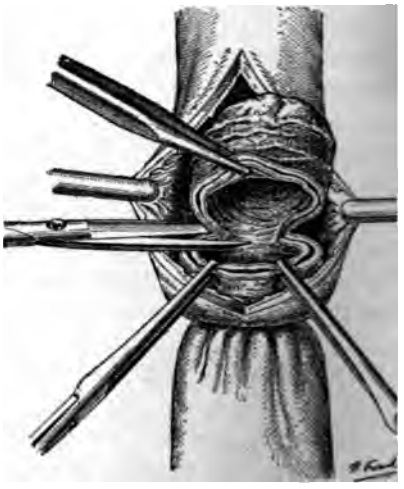


FIG. 603.

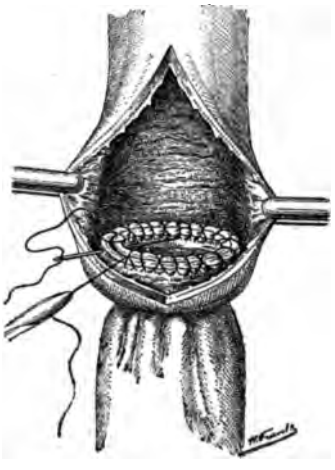


FIG. 604.

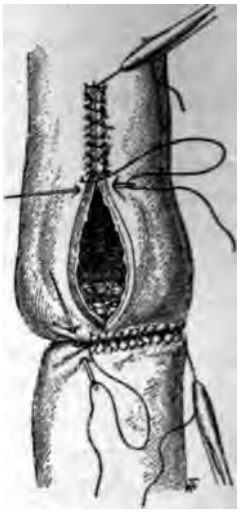


FIG. 605.

FIGS. 602 TO 605.—Intussusception. (*Guibe.*)

Intussusception.—Open the abdomen. Discover the site of the ob tion and attempt to reduce it.

Reduction of the Intussusception.—With the fingers of one hand gently the entering bowel close to the invagination; with the other hand take h the bowel immediately below the intussusceptum and gently press, stroke, milk the intussusceptum upwards. *Make no traction or massage.* If

obtained, examine the involved gut most carefully, lest it should be in-
If an elongation of the mesentery seems to have had anything to do
he production of the intussusception, it is easy to shorten it by throwing
folds and inserting a few stitches. If this is done, be careful *not* to inter-
ith the free passage of blood to the gut through the mesentery. If reduc-
impossible, and it frequently is, several methods of treatment are possible:
Excision of the portion of gut involved. The operation is identical
the enterectomy described elsewhere, and is only permissible when the
susception is limited in extent.

FIG. 606.—Intussusception. (*Coffey, Annals of Surgery.*)

Excision of the intussusceptum. (Figs. 602, 603, 604, 605 explain the
tion fully.)
. C. Coffey in a remarkable paper on intussusception ("Annals of Surgery,"
ary, 1907) recommends the following operation: After exposing the af-
d gut by laparotomy make the primary incision (Fig. 606) into the intus-
piens. Withdraw the intussusceptum and wrap it in gauze (Fig. 606).
the distal end of the intestine with gauze (Fig. 606). Cut the middle
of the intussusceptum by a circular incision (Fig. 607). Catch any bleed-
oints with forceps (Fig. 607). Doubly clamp and divide the healthy in-
e (Fig. 607 and Fig. 608). Complete the primary incision, laying open
istal end of the ileum and freeing the intestine to be removed (Fig. 607).
the distal end to the gut with sutures (Fig. 608). (Coffey advises making
osure only partial so as to anastomose the proximal segment of the ileum

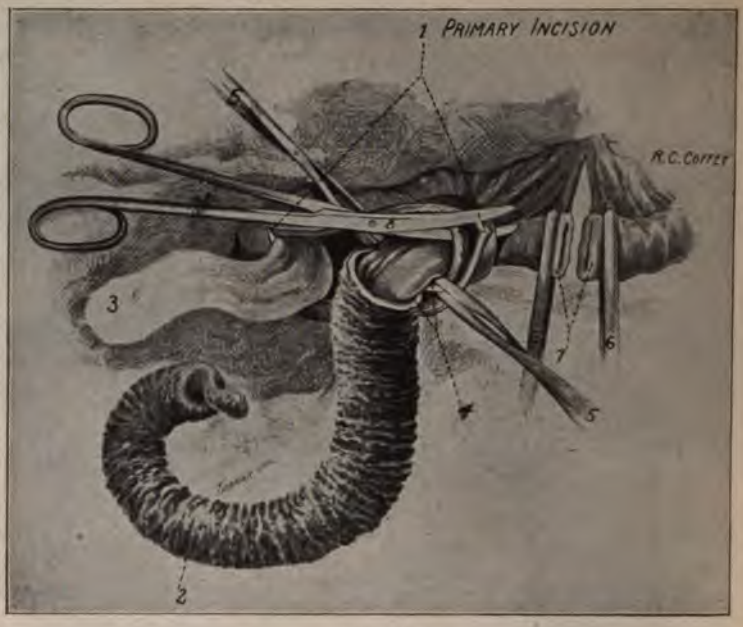


FIG. 607.

2. Intussusception withdrawn. 3. Pack in distal end gut. 5. Circular incision of middle layer o tussusceptum. 5. Forceps on vessels. 6, 7. Ileum divided between clamps. 8. Completion of primar incision. (*Coffey, Annals of Surgery.*)

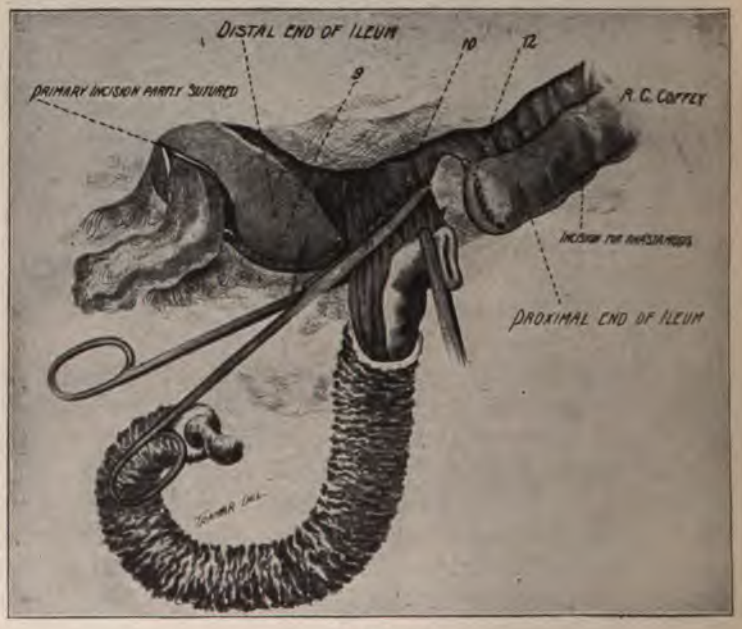


FIG. 608.

9. Partial suture distal and ileum. 10. Mesentery ligated. 11. Division of mesentery. 12. Prox gut closed. (*Coffey, Annals of Surgery.*)

it. It will probably be better to close the gut entirely and make a lateral astomosis.) Ligate the mesentery (Fig. 608). Divide the mesentery and move the gangrenous gut (Fig. 608). Close the proximal end of the ileum ig. 608). Make an anastomosis between the proximal and distal segments ileum.

K. Israel impressed by the dangers of soiling the peritoneum during excion first delivers the intussuscipiens, sutures its serous coat to the parietal ritoneum, then opens it and excises the intussusceptum as above. He advises is method in all types of intestinal stricture producing a temporary artificial tussusception as in Maunsell's operation.

3. Ellsworth Eliot, Jr., suggests that the affected portion of gut be brought ar the abdominal wound; a small incision (O) (Fig. 609) be made near the d of the intussusceptum through the gut wall just below the lesion; a soft atheter (T) be passed through this wound and through the canal of the intusisceptum into the gut above; the incised gut be sutured to the parietal wound

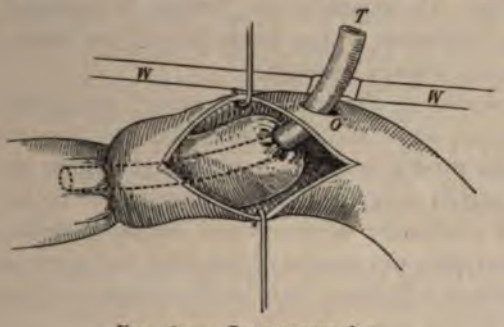


FIG. 609.—Intussusception.

W) (Fig. 609). The result is an artificial anus below the obstruction, prenting increase of the intussusception and providing intestinal drainage through he catheter. Eliot thinks the method may be of use in the case of young hildren. It is only mentioned here as a suggestion.

4. Instead of enterectomy, the operation of segregation may be employed, r an anastomosis may be established between the open gut above and below he lesion.

5. Under certain circumstances, *e.g.*, prostration, etc., it may be wise to nake an artificial anus, whether accompanied by excision of the intussusception or not. The prognosis must always be bad when the intussusception is eft unreduced, even though the continuity of fæcal circulation is provided for, s gangrene or inflammation of the involved intestine is liable to occasion a atal peritonitis.

The vital importance of early operation in intussusception is clearly demonrated by Clubbe's statistics. ("Brit. Journal Children's Diseases," July, 909.) During the year 1908 there were thirty-three cases of intussusception treated in the Royal Alexandra Hospital for sick children in Sydney with ly two deaths. During the same period Clubbe himself treated twenty-six es without a death. These remarkable results Clubbe attributes to the ly diagnoses made by the physicians who first saw the cases. None of the

patients were seen by him later than fifty-three hours from the beginning of the trouble. In his opinion laparotomy constitutes the only treatment. Clubbe's total experience consists of 157 operations for intussusception with the following striking results: Of the first fifty patients twenty-five died, *i.e.*, 50 per cent.; of the second fifty patients twelve died, *i.e.*, 25 per cent.; of the third fifty patients four died, *i.e.*, 8 per cent.; of the last seven patients none died, *i.e.*, 0 per cent.

The stomach may become twisted on itself, the axis of the twist corresponding more or less to the lesser curvature. Gastric volvulus may be:

A. *Total, i.e.*, almost the whole of the greater curvature with attached gastrocolic omentum passes forwards and upwards to lie between the lowered lesser curvature and the diaphragm. The torsion may be to 180° as described above and the true posterior surface of the organ present anteriorly often covered by the mesocolon, as the colon is commonly dislocated with the stomach and lies under the diaphragm. Total volvulus occasions occlusion of both the cardiac and pyloric orifices. Occasionally the torsion is posterior, *i.e.*, the greater curvature passes backwards and upwards behind the lesser curvature. Total volvulus is acute and usually primary.

B. *Partial Volvulus of Stomach.*—Frequently secondary to inflammatory lesions, to neoplasms or to diaphragmatic hernia. The trouble is commonly chronic. Here the torsion is of the pylorus and pyloric end of the stomach. Both total and partial volvulus demand operation. In partial volvulus the trouble will most commonly be discovered during operation for the primary lesion and the treatment will consist of detorsion and correction of the primary lesion, *e.g.*, division of adhesions; cure of diaphragmatic hernia; treatment of hour-glass stomach, etc., etc.

In total volvulus diagnosis has on several occasions been made prior to, but more frequently during operation. The story of the operation is usually as follows: Median incision from the ensiform cartilage to the umbilicus. On opening the abdomen a large cyst presents covered by a vascular membrane, the mesocolon. It is impossible to orient the cyst because of tension, etc. Tear a hole through a non-vascular area of the membrane. Protect the abdominal cavity very thoroughly with gauze pads. Puncture the cyst as high up as possible and drain its contents through a cannula. Close the puncture in the cyst by a double row of sutures; the second row being of the Lembert sort. Exploration is now easy and the cyst is found to be the stomach which is recognized by the arrangement of its arteries and the attachment of the great omentum. Usually detorsion is easy. If the patient's strength permits it is recommended to insure against recurrence by performing gastropexy, *i.e.*, by fixing the anterior surface of the stomach near the lesser curvature to the abdominal wall by a row of sutures. Lenormant ("La Press. Med.," May 11, 1912) has collected 11 cases of total volvulus with 7 recoveries and 6 cases of partial volvulus with 5 recoveries. (For information regarding gastric volvulus see Payr, "Mittheilungen d. Grenzgeb.," xx, 686; Lenormant, "La Presse Med.," May 11, 1912; Tuffier and Jeanne, "Rev. de Gyn. et Chir. Abdom.," Jan., 1912.)

Volvulus.—Open the abdomen. Find the site of obstruction. Empty the gut by incision. Gently endeavor to unravel the knotted or twisted intes-

e. If reduction is impossible and there is no interference with the blood-
ply of the involved gut, establish an anastomosis between the gut above
l below. If the blood-supply is threatened or if for other reasons the step
ms proper, excise the involved gut. Where radical treatment is impossible,
operation of intestinal exclusion or segregation may be employed.

Finsterer ("Zent. für Chir.," No. 30, 1912) finds that simple detorsion has a
rtality of 35 per cent. and there were 13 recurrences in 48 cases. Colopexy
course following detorsion) gives a mortality of 20 per cent.,and is no surety
inst recurrence. Entero-anastomosis has a mortality of 50 per cent. When
ıgrene is present resection is compulsory and should be done in two stages;
n when the gut is not gangrenous, resection gives the best results (mortality
per cent.). If the general condition of the patient permits, the operation
y be done in one sitting. (In 23 operations, 1 death.)

A curious cause of chronic obstruction and the most frequent cause of
vulus of the sigmoid colon is the so-called "retractile meso-sigmoiditis."
From some ill-defined cause the base of the meso-sigmoid becomes covered
ısversely by bands of scar tissue which contract and in severe cases may
ıg both segments of the sigmoid together like the barrels of a gun. This of
rse can cause narrowing of the lumen and obstruction with subsequent
ıtation of part of the sigmoid loop and of the descending colon. Distention
the bowel and interference with the circulation are liable to lead to ulcera-
ı of the mucosa, etc. Fixation or stiffening of the sigmoid is a predisposing
ıse of volvulus.

Treatment.—If the bowel does not seem severely affected, divide the bands
scar tissue which contract the meson; in some cases this permits the meson
spread out to its normal condition. If the above measure fails to release the
son or if the gut is much affected it is advised
resect the involved intestine. In some cases
anastomosis might overcome the trouble.
uval, "Arch. des malad. de l'appar. digestif,"
07, No. 1; "Ref. Centralblatt für Chir.,"
07, No. 37).

FIG. 610.—Summers' method.

Bands, Etc.—Bands or strands of omentum,
:., causing obstruction are to be doubly
ated and divided, or rather excised. When
viding such bands examine them carefully
it they should consist of diverticula with mucous lining, in which case
ey must be treated in the same fashion as the stump left by the excision of
e vermiform appendix.

Sometimes bands pressing on the gut cause gangrene, the gangrene involv-
; all or nearly all of the circumference of the gut while it involves little of the
g axis of the gut. This segment of gut may be excised though it is probably
ch better, especially in the feeble, to invaginate the gangrenous gut by a
r of Lembert sutures. The invaginated tissue is dead and soon sloughs
leaving the lumen of the gut patent (Fig. 610). This operation was de-
d by J. E. Summers and carried out successfully by him in three cases;

two of these were strangulated herniæ and one was of gun-shot wound of the intestines.

Adhesions.—The best treatment for obstruction from adhesions, to use an Irishism, is *not* to have the adhesions. The principal *prophylactic* means to this end is, when operating, to leave as few raw surfaces as possible within the belly. Wherever possible, raw surfaces, pedicles, etc., should be covered with peritoneum, even if some plastic work be required for this purpose. Where it is impossible to cover the surfaces with neighboring peritoneum, portions of omentum may be ligated and cut off, and these fragments plastered over the raw surface. Finton and Peet (Surg., Gyn. and Obst., Sept., 1919) find that these omental grafts in the absence of infection are alive and good after the lapse of six months. If infection is present they are useless *except* as temporary means of preventing extravasation of intestinal contents until protection adhesions form. These authors find that under sterile conditions, free omental flaps prevent the formation of adhesions. The *active* treatment of adhesions is to break them up, either by sharp or blunt dissection, and cover the raw surface as above described. When a gut is adherent to the parietal peritoneum or to an organ of lesser importance, and in freeing it injury to one or the other is probable, be careful to sacrifice the less rather than the more important organ. If it is impossible safely to separate the adhesion causing obstruction restore the fæcal circulation by establishing an anastomosis between the gut above and below the obstruction.

Foreign Bodies.—For the treatment of obstruction due to this cause see remarks on enterotomy (page 411).

Enterostomy.—The term "enterostomy" signifies an operation to establish a communication between any portion of the intestine and the exterior of the body, whether this opening be used for the introduction of food, etc., or for the evacuation of intestinal contents.

Jejunostomy.—This operation is of value in providing absolute rest to the stomach in cases of hemorrhage when other more direct methods of treatment are unavailable. Mayo Robson ("Brit. Med. Journ.," Jan. 6, 1912) thinks jejunostomy of great value in jejunal ulcer following gastro-enterostomy when the patient is too feeble to permit of more extensive work. He finds it also valuable in "ulcer near the cardiac end of the stomach, or along the lesser curvature as also in some ulcers of the duodenum that have failed to yield to medical treatment" if there is no pyloric stenosis. v. Milkulicz considers jejunostomy "inhuman" when used to prolong life in cases of stenosis from gastric cancer.

The Operation.—Expose and examine the stomach exactly as in gastro-enterostomy in order to prove that some other and better operation than jejunostomy may not be possible. Bring a loop of jejunum, 6 to 8 inches below the duodenojejunal angle, into the abdominal wound and suture it to the fascia and skin. Close the excess of parietal wound. Either at the same sitting or a few days later make an opening into the exposed portion of jejunum of a size sufficient for the introduction of a soft-rubber catheter. Feed with predigested food through the catheter.

An imitation of the Stamm-Kader operation may be used or, better still, of the Witzel gastrostomy. The great objection to jejunostomy is the constant

d inevitable escape of bile and pancreatic juice through the fistula. To viate this evil Maydl, after exposing the jejunum, divides it transversely out 8 inches below its origin; the open end of the upper segment he implants to the side of the lower, about 8 inches below the line of section, and then nites the open end of the lower segment to the skin. The principle is identical ith that of Roux's gastro-enterostomy, and is most excellent; the only criticism n it is that patients requiring jejunostomy are usually in a very feeble condition nd cannot withstand much operative interference.

Instead of a rather complicated Maydl operation, one may take an entero-nterostomy between the afferent and efferent segments, and, if desired, ob-literate the lumen of the afferent segment, by means of a purse-string suture, between the site of the anastomosis and the fistula.

Colostomy (often called colotomy).—The most common indication calling for colostomy is obstruction, and then, according to the method of operating adopted, either a part or the whole of the intestinal contents escape through the artificial anus. When operation is indicated for the application of remedies (douches, etc.) to the inside of the colon some method is adopted by which escape of fæces is prevented (see cæcostomy) or appendicostomy is substituted for colostomy.

Lumbar Colostomy.—The operation is practically the same whether it is done on the right or the left side. Right lumbar colostomy is very valuable in colonic obstruction when the cause of the obstruction can be subsequently removed. For permanent artificial anus the left inguinal region is preferable. The following description applies to the left lumbar colostomy:

Step 1.—Place the patient on his right side with a firm rounded pillow under his right loin. Find a point on the crest of the ilium midway between its anterior and posterior superior spines. From a spot a little in front of and 1 inch above the mid-point of the ilium, make an incision, 3 to 4 inches in length along an imaginary line leading to the junction of the spine and the last rib (Bryant's incision). Divide the skin and subjacent muscles along the whole length of the superficial incision. Attend to hemostasis. Expose and divide the transversalis fascia, exposing the subperitoneal fat.

Step 2.—With blunt dissection penetrate the exposed fat in which the colon is to be found. The colon may always be discovered in front of the lower border of the kidney. Be careful not to open the peritoneum; but if this accident occurs, make use of the opening to aid in locating the colon; which being done, close the peritoneum either by suture or ligature.

Step 3.—*Method A.*—Having found the colon, pull it up into the wound and pass a stout suture through the skin (not the muscles) on one side of the wound, through the colon, and out through the skin on the other side. Clean the lumbar wound and close its deep parts with a few catgut sutures. Close the superficial lumbar wound with silkworm-gut, except opposite the prolapsed gut. Make a small opening into the gut over the suture which traverses its lumen. Pick up and pull out the centre of the suture traversing the gut and divide it. Tie the two halves of the suture and thus fix the sides of the intestinal opening to the skin. Introduce any more sutures which may be necessary.

Method B.—Operate as above, but instead of merely incision of the colon, completely divide it, close its lower segment completely, and suture the whole circumference of the upper segment to the skin (Madelung).

Method C.—Bring a knuckle of gut outside the wound, protect it with dressings, and open it after the lapse of three or four days. Any lumbar wound which is in excess of what is required for the passage of the gut must be closed by sutures. It is unnecessary to fix the gut in the wound by means of sutures.

Inguinal Colostomy.—When the operation is done on the left side, it may be named sigmoidostomy, but the operation is practically the same whether it be a right inguinal colostomy or a sigmoidostomy. A sigmoidostomy will be here described.

Step 1.—Draw an imaginary line from the anterior superior spine to the umbilicus; make an incision 2½ inches long, crossing this line at right angles and distant 1½ inches from the anterior superior spine. One-half the cut is above the line and one-half below (Harrison Cripps' incision).

Step 2.—Find the colon, recognizable from its longitudinal muscular bands and appendices epiploicæ. Pull it into the wound.

Step 3.—*Method A.*—Pass two silk sutures, two inches apart, through the free margin of the gut. These are for traction purposes and serve as guides. Suture the loop of gut to the edges of the inguinal wound. If the case is urgent, open the gut at once; if there is no urgency, apply dressings and incise the colon after the lapse of three or four days. In this operation there is no attempt made to compel the complete evacuation of the bowel through the artificial opening; much of the colonic contents are at liberty to pass down into the lower gut.

Method B.—Gently pull out of the wound as much of the upper segment of gut as will come down and push it back again through the lower angle of the wound. This is done so that the intestinal opening may be made in a part of the gut well supported by mesentery, and thus prolapse be avoided. Introduce traction sutures as in Method A. Suture the protruded loop of gut to the abdominal wound. The sutures should be so placed that at least two-thirds of the circumference of the gut is external to the line of stitches. Open the gut either immediately or after the lapse of 3 or 4 days. The object of making so much gut protrude is to form a spur or obstacle to the passage of fæces into the lower segment of bowel. Paul thinks a spur is usually disadvantageous and so does not permit so much of the circumference of the gut to be external to the line of stitches.

Method C is almost the same as Method B. After pulling the gut downwards so as to obtain mesenteric support, pass a glass rod under the selected loop of gut, through its mesentery. The ends of the glass rod rest on each side of the skin-wound and support the loop of gut (Fig. 611). Close the belly-wound, leaving sufficient room for the passage of the loop of gut held in place by the glass rod. Apply dressings. Remove the glass rod and open the gut after union has taken place between the gut and the parietes. In opening the gut it is best to divide it transversely and slowly with the thermocautery. If there is an excess of gut protruding, it may well be excised with the cautery. No anæsthetic is necessary as the intestine is

ot sensitive. This is a convenient and good method. A variant in the ıethod is (1) after opening the abdomen suture the parietal peritoneum to ıe skin. (2) After the glass rod is in position suture the intestinal serosa to ıe parietal peritoneum or to the skin.

Method D.—Find the colon, pull it downwards so as to provide mesenteric ıpport. Apply clamps to the gut and divide it. Close the lumen of the lower :gment by inverting its cut edges and suturing. Suture the whole circum-:rence of the upper segment to the skin. Close the excess of skin-wound after :moving the clamps.

FIG. 611.

FIG. 612.

FIGS. 611 AND 612.—Colostomy.

Methods E and F.—Instead of dividing the gut, and before opening it, Mosetig-Moorhof creates a valvular obstruction in the lower segment by inserting a few Lembert sutures (Fig. 612). The same object may be attained by encircling the gut with a loop of wire or with a purse-string suture of silk.

Method G (Wyeth's Operation).—All the methods already described have been devised in the belief that prolapse of the afferent segment of the gut is the principal trouble after colostomy. This belief is not correct. The chief trouble is that there is no rectum to act as a natural reservoir for fæces. The following operation provides such a reservoir and also prevents any great prolapse of mucous membrane.

FIG. 613.—Cripps' incision.

Step 1.—Make an incision through the skin alone, parallel to and 1¼ inches below the Harrison Cripps' line of incision (page 454). Pull the superior edges of the skin incision upwards so as to expose the deep structures of the belly-wall at the Harrison Cripps' line (Fig. 613). Divide the deep structures along this line and so open the belly.

Step 2.—Pull the sigmoid flexure out of the wound; push all excess of sigmoid *up* into the belly so that as little gut is left below the eviscerated loop as possible, *i.e.*, the portion of gut to be united to the belly-wall is chosen as low down the intestine as is possible. By this means a fæcal reservoir is provided.

Step 3.—Treat the eviscerated segment of gut in much the same manner as is recommended in the preceding methods. If it is desired to open the gut

at once, it is wise to fasten a tube into it by means of a purse-string suture, m in the manner described in Paul's colectomy. Some surgeons strongly ad against suturing the parietal peritoneum to the skin, as when this is done th is not such good union between the gut and the parietes. Excise all the app dices epiploicæ from the eviscerated segment of gut, as otherwise they w surely slough off, slowly and with much stench. In applying dressings alwa separate the dressings from the exposed gut by a layer of rubber tissue or perf

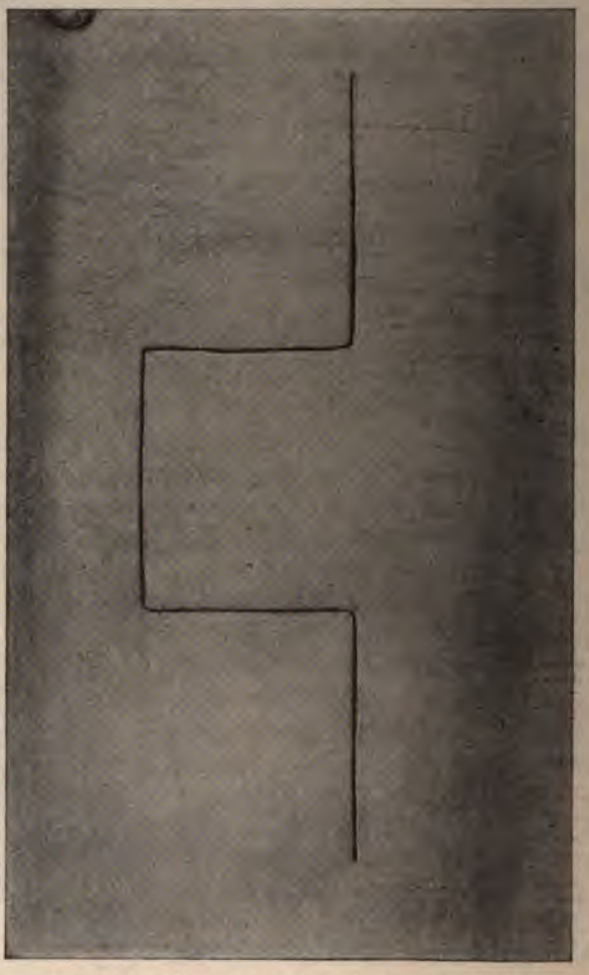


FIG. 614.—Mixter's anterior colostomy. (*Gould.*)
Line of incision.

rated oiled silk. This simple device saves much trouble from the sticking dressings to the parts and is very conducive to cleanliness and avoidance stench. In time the opening in the skin and that through the deeper structur come to lie close to each other; not so close, however, as to do away with t valve action desired.

Method H.—Mixter's anterior colostomy.

Step 1.—Make the incision shown in Fig. 614. The outer portion of t

n must be a short distance inside of the outer edge of the rectus muscle. ncision divides the skin, subcutaneous tissue and the rectus fascia. Reflect rds the quadrilateral flap outlined. It seems an unnecessary complica- o make the rectangular flap of skin. A vertical incision answers every se and can be closed under the protruding portion of gut in the same way together with the rectus muscle and sheath.

FIG. 615.—Anterior colostomy. (*Gould.*)
withdrawn, mesentery pulled taut and incised. Rectus muscle sewed together between afferent and efferent coils.

p 2.—Split the rectus muscle near its outer margin. Open the abdomen.
p 3.—Deliver a loop of the sigmoid as in Step 2, Method G.
p 4.—Split the meso-sigmoid for about 2 inches at a right angle to the xis of the bowel. Suture the two edges of the middle portion of the ted rectus muscle together through the opening in the meso-sigmoid 615).

Step 5.—Push the reflected flap of skin and rectus fascia through the ing in the meso-sigmoid and suture it in its original position (Fig. 616).

After four or five days the exposed coil of sigmoid may be resected, bleeding from the cut ends of the intestine may be controlled by a cont suture of catgut. The proximal and distal openings are wide apart a

FIG. 616.—Anterior colostomy. (*Gould.*)
Flap fastened into original position under arch of sigmoid, with two layers of sutures. Mixter tube

rectus acts as a sphincter. Through the distal opening it is easy to flu rectum (Fig. 617). If obstruction is acute one may open the bowel i 5 and insert a glass tube (Paul's tube; Mixter's tube).

Method I.—Littlewood's Colostomy.—Make a vertical incision from t of the twelfth rib on the left side downwards to a point behind the a superior iliac spine. Expose the descending colon and open it as far b possible on its outer side so as to leave no chance for the small intes find a niche in which it may become strangulated. This operation number of important advantages. The new anus is far from hairs and

mparatively sanitary. Almost any belt around the waist will suffice to an occlusive pad in position.

Method J.—McGavin's Transversostomy (Clin. Soc. Trans., 1906; Brit. Med. rn., May 10, 1913).—Make a vertical incision 2 inches to the left of the ea alba and with its upper end 2 inches below the costal margin. Split

FIG. 617.—Anterior colostomy. (*Gould.*)
Sigmoid resected ¼ to ½ inch above skin level. Circumference of cut edges sewed with catgut.

e rectus. Open the abdomen. Pull out the transverse colon so as to form a od "spur" and complete the operation as in Method C. There is much to said in favor of McGavin's method. The patient can subsequently care for mself easily. An occlusive pad is efficient and easily worn. The rectus scle forms a fairly good sphincter. The colonic contents are not so foul as those of the sigmoid and while not so solid are yet sufficiently so. The anus is remote from the disease.

Method K.—Cæcostomy.—The author has found this operation of value substitute for appendicostomy. In autopsies on those dying from corrosive

sublimate poisoning, C. C. Conover found that the mucosa of the pyloric end of the stomach is affected being black in color, but that the muscular and peritoneal tunics are not seriously involved, that the small intestine escapes damage, that the cæcum and colon are the sites of severe ulceration. The colonic ulceration begins within twenty-four hours of the swallowing of the poison and death occurs usually within thirty-six hours. Adami (Brit. Med. Journ., Jan. 24, 1914) writes, "we have clear evidence that the mucosa of the colon is a region of active excretion; we know, for example, that antimony and mercury are discharged from the blood by this path." Conover suggested that early cæcostomy with lavage of the colon every three hours (better continuous lavage) kept up for from two to four days might prevent the colonic ulceration. Conover's treatment has been carried out in a few cases at the Kansas City General Hospital with uniformly good results.

L. L. McArthur finds that irrigation of the colon through an appendicostomy or cæcostomy opening is of actual curative value in tuberculous ulceration in any portion of the gut distal to the caput coli. This includes of course the sigmoid and rectum.

FIG. 618.—Cæcostomy.

Step 1.—Expose the cæcum by means of the McArthur-McBurney muscle-splitting method.

Step 2.—Choose a part of the cæcum which can be easily approximated to the abdominal wound and introduce a purse-string suture of catgut (Fig. 618) penetrating the whole thickness of the cæcal wall.

Step 3.—Incise the gut inside the circle formed by the purse-string suture. Through this incision pass the bulb of a Pezzer's self-retaining catheter into the lumen of the gut. Tie the purse-string snugly around the shaft of the catheter but not tightly enough to obstruct its lumen. No fæcal matter can now escape alongside the catheter and no bleeding from the intestinal wound is possible. Cleanse the field of operation.

Step 4.—At a distance of ¼ to ½ inch from the catheter introduce a purse-string suture of hemp or silk and tie this line of suture snugly (but not too tightly) around the shaft of the catheter. Leave the ends of the suture long. Instead of the above method a modification of the Witzel plan for gastrostomy may be used.

Step 5.—Pull the free end of the catheter through the abdominal wound so as to bring the cæcum into apposition with the parietal peritoneum. Stitch the long ends of the purse-string suture to the parietal peritoneum. Close the abdominal wound. Before applying dressings pull the catheter in such a fashion that its bulb (inside the cæcum) will bring the cæcum into contact, with the parietal peritoneum. Before closing the abdominal wound, the cæcum, near the catheter, may if desired be united to the parietal peritoneum by one or two stitches. This is rarely necessary. Before introducing the catheter into the cæcum its free end may be clamped by a hemostat.

The catheter is left *in situ* as long as it is required for irrigation of the colon. remove the catheter cut it flush with the skin and with a probe passed rough the lumen of the remnant poke the bulb into the gut. Owing to the vagination of the cæcal wall the fistula closes promptly as soon as the catheter removed.

Weir suggested that the appendix might be used in the formation of a fistula rough which the colon could be irrigated. The operation is only feasible hen the appendix has a lumen large enough to permit the passage of a small atheter and when absence of adhesions and presence of sufficiently long meso-ppendix permit its being brought out through the abdominal wall without nterference with its nutrition.

Step 1.—Open the abdomen through a small incision as for appendectomy.

Step 2.—Bring the appendix out through the wound without twisting or exerting undue pressure on its meson.

Step 3.—Prevent retraction of the appendix into the abdomen either by uniting the cæcum or the appendix to the parietes by one or more sutures, or by passing a safety-pin through the meso-appendix exactly as a rubber drainage-tube is secured.

Step 4.—Close the abdominal wound being careful not to exert pressure on the appendix or its blood-supply. After adhesions have formed between the appendix and the wound cut off the protruding tip of the appendix flush with the skin and introduce a soft-rubber catheter into the cæcum as often as may be required. When it is desired to close the fistula remove the mucosa of the appendix either by the cautery or by dissection or remove the appendix itself.

Closure of Artificial Anus or of Fæcal Fistulæ.—If the colostomy opening is small the patient may be kept in comfort by careful regulation of the bowels and by plugging the fistula with a mushroom-shaped aluminum plug held in place by a pad and belt. When colostomy has been performed as a preliminary step in excision of the rectum or for therapeutic purposes, or when the obstruction which called for it has been removed, it becomes necessary to close the artificial anus. When no "spur" preventing the onward passage of fæces is present, all that may be required is to dissect the mucous membrane free from the skin, turn it inwards, stitch its edges together, and then suture the now raw edges of the abdominal wound. When a "spur" is present (*vide* Methods B and C, page 454), one may apply a clamp to the spur and leave it in position until by pressure it causes the "spur" to slough away (Fig. 619). This takes away all opposition to the onward flow of the contents, and the fistula may be closed in the manner already described. Such was the manner of operating devised by Dupuytren, and until comparatively recently was the accepted method. The dangers of the method are: (*a*) peritonitis; (*b*) accidental inclusion of a knuckle of intestine within the clamps. Other nd more precise methods are now in use.

The Operation.—Mummery (Surg., Gyn. and Obst., Sept., 1919, p. 312) adises very careful preparation. The skin is commonly much excoriated around he fistula especially in fistulæ of the small intestine or cæcum, and this must e corrected. Give opium in doses sufficient to produce considerable constipaion and if possible solid stools. Protect the skin by ointments. After a week

or more there will be much improvement. Before operation do *not* purge, but empty the gut by lavage.

Step 2.—Cleanse the skin around the fistula and scrub the fistula itself. Cauterize the fistulous opening with the thermocautery, liquid carbolic acid, or pure formalin. Close the opening tightly with a purse-string suture after packing it with a small plug of gauze. A suture is inserted in the skin, and when tied prevents soiling of the neighborhood by intestinal contents (Fig. 620, L). Once more cleanse the field of operation.

Step 2.—Make an incision through the parietes at a point above, below, or to the side of the fistula, and open the abdominal cavity. In choosing where to make this incision endeavor to find a spot close to the fistula where the tissues are not much altered, and where the viscera are not adherent to the parietal peritoneum.

FIG. 619.

FIG. 620.

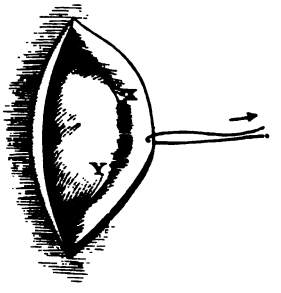


FIG. 621.

FIGS. 619, 620 AND 621.—Closure of fæcal fistulæ. (*Esmarch and Kowalsig.*)

Step 3.—Introduce the finger into the belly and explore the relations of the adherent gut to the abdominal wall. Guided by the exploring finger, enlarge the incision, making it run around one side of the fistulous opening (Fig. 620, I, N).

Step 4.—Retract the flap formed by the incision I, N. This exposes the gut and its connection with the inner surface of the parietes at the fistula (Fig. 621, X, Y).

Step 5.—*Method A.*—If the connection between the gut and the parietes is small in extent, empty the gut of its contents by stripping it with the fingers, and keep it empty by suitable clamps. Protect the abdomen with pads; divide the union between the gut and the parietes; close the hole in the gut by a double row of sutures, as is done in enterotomy.

Method B.—If the connection between the gut and the parietes when separated leaves such a defect that simple closure would lead to stenosis, either counteract the effect of the stenosis by anastomosing the afferent and efferent loops or excise the injured portion of gut and restore the continuity of the gut [illegible] done after any enterectomy.

[illegible] *C.*—If the union between the gut and the parietes is very extensive, [illegible] any reason the above methods are inapplicable,—*e.g.*, presence o

ve and dense adhesions, or the inaccessible location of the fistula,—then
ration of bilateral exclusion may be performed. In this case the next
the operation, after the exclusion has been accomplished, would be
of the abdominal wound and removal of the purse-string suture around
ula, as that opening is required for the drainage of the excluded segment
A cure of the fistula may be expected, but only after a lapse of much
The method by "exclusion" and "segregation" is not a method of choice,
necessity, and when done, removal of the mucous membrane from the
ted gut, if possible, is an advantage.

6.—The continuity of the gut having been established, excise the fistula
much of the surrounding sclerosed tissue as may be necessary to secure
structures for suturing. As a rule, in severe cases, the whole of the
tlined by the cut I, N, Fig. 620, will require removal, and sometimes
ore tissue must be sacrificed.

7.—Close the abdominal wound, preferably without drainage.

operation thus described will generally be found satisfactory. Its ex-
rendered necessary from the fact that the fistula is usually surrounded
ch scar tissue which, unless thoroughly extirpated, will almost surely
the formation of a post-operative hernia. In a few cases where there is
ch deposit of scar tissue and where the fistulous track is short and leads
into the gut, a much simpler procedure may be adopted.

1.—After thorough cleansing of the fistula and the whole neighboring
ake an incision around the fistula at the junction of the skin and mucous
ane. Through this incision dissect the fistulous track free from its sur-
gs until the gut is reached.

2.—The fistulous track is now attached to the gut alone, and hangs on
much as the vermiform appendix hangs on the cæcum after the appen-
mesentery is divided. Remove the fistulous track in the same manner
appendix is excised and treat the resulting stump similarly.

3.—Close the abdominal wound with or without drainage.

ead of operating as above, one may open the belly in the middle line,
loops of gut leading to and from the artificial anus, and make an anas-
between them, subsequently closing the fistula. In this method it is
asier to keep the peritoneum from being soiled than in the preceding.

en it becomes desirable to close the artificial anus made by dividing
tely the gut, closing and dropping its lower segment into the belly, and
g the upper segment to the abdominal wound, the operation to be chosen
lone on the following lines:

pty the bowels by means of purgatives or enemata. Administer an
hortly before operating to lock up the bowels. Pack the artificial anus
uze to prevent escape of contents during the operation. Open the
referably in the middle line. Find the lower segment of gut. Find the
gut which is attached to the skin and forms the artificial anus. Make
tomosis between the lower segment of gut and loop of gut above that
orms the artificial anus. Close or excise the artificial anus either at the
tting or subsequently. Close the abdominal wound.

Mummery (*Loc. cit.*) gives advice very similar to that given in the preceding paragraphs but is especially insistent on the following principles. (1) Open the abdomen freely to one side of and well away from the fistula. (2) Completely free the gut and fistula in one piece, draw them out of the abdomen and thus complete the operation with comparative freedom from risk of peritoneal contamination. (3) Cut away involved bowel until unmistakably healthy tissue is reached. This may require complete resection of a segment of bowel or as is more common may require closure of a large wound in the gut. (4) Large wounds should be trimmed as in Fig. 622 so that their edges are freely nourished. The cut edges which are going to be joined should form roughly an angle of 45° with the mesenteric border. (5) During the days following operation the rectum ought to be kept clear by means of lavage (do *not* inject water under any pressure) and the bowels kept open by giving paraffin oil and small doses of salts.

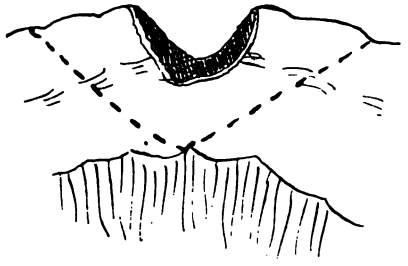


FIG. 622.

CHAPTER XXXV

THE VERMIFORM APPENDIX AND PERITONEUM

OPERATIVE TREATMENT OF APPENDICITIS

Appendicectomy.—As different methods have been devised for carrying out almost every step of appendicectomy, it may be convenient to describe shortly a number of these methods under the headings Step 1, 2, etc.

Step 1.—*Opening the Abdomen.*—(A) *McBurney Method.**—This method is especially suitable where no drainage of the abdominal cavity is required; drainage, however, may be effected either through the wound itself or better, through a special stab wound made in a convenient position. Under proper conditions the method is ideal. The principle involved is avoidance of transverse division of muscles or tendinous fibres, so that when healing has taken place there is no post-operative weakness of the belly-wall.

The Operation.—Make a three-inch incision through the skin and subcutaneous fat. The cut begins at a point one inch above a line joining the anterior superior spine of the ilium and the umbilicus, and crosses it at a point one and one-half inches from the anterior superior spine. The incision runs downwards and inwards in the same direction as the fibres of the external oblique muscle and aponeurosis. Separate the fibres of the external oblique for the whole length of the wound without cutting any of them transversely. With retrac-

*L. L. McArthur undoubtedly devised and carried out this muscle-splitting operation about thirty cases before McBurney did so. Unfortunately he failed to publish his method early enough. Needless to say McBurney was not acquainted with the above fact when he described his operation.

apart the edges of the wound in the external oblique and expose rlying internal oblique and transversalis muscles, whose fibres run ately at right angles to the superficial wound. With blunt dissec- erse these muscles so as to make a wound in them, parallel to their l at right angles to wound in the external oblique. Blunt retractors luced to keep this wound open and expose the fascia transversalis, divided in the same direction as the wound of the internal oblique. the peritoneum is picked up in forceps and opened. Special care taken in opening the peritoneum, as it is frequently found adherent ecum or other abdominal contents. The same rules apply to the f the peritoneum as to the opening of the sac in cases of hernia.

e of the Wound.—Separate suture of the peritoneum and of the trans- ascia. The wound in the internal oblique and transversalis muscles ut one or two points of suture. Suture of the external oblique. the skin. Suture material varies according to the fancy of the opera- author prefers catgut.

appendix is long and extends far up towards the liver its distal end posed through a second incision entirely similar to the first but at a el. Working through both incisions a difficult operation may be litated and no greater danger of post-operative hernia incurred.

er to obtain more room Weir, after splitting the fascia of the external eparates it from the anterior surface of the rectus, splits the internal nd transversalis like McBurney, but continues the split or incision ly through the anterior layer of the sheath of the rectus, retracts the lf towards the middle line, and lastly divides the posterior layer of sheath along with the peritoneum. Closure of this wound presents difficulties. Note that in dividing the posterior layer of rectus sheath tric vessels ought to be found and ligated before division. In Weir's retraction of the rectus inwards may possibly injure or tear the nerves; the author modifies the method by dividing the rectus as far as neces- suturing, in two lines, the aponeurosis covering it anteriorly to the He also often reverses the steps of the operation, beginning by trans- ion of the rectus in the interspinous line and afterwards, if necessary, the wound outwards and upwards in the gridiron fashion.

Shaw (Northwest Med., May, 1916) uses the gridiron incision in acute is but centers it one inch lower than in the original operation. This direct access to the appendix and avoids the danger of injuring the tercostal nerve. If more room is required it may be obtained by Harrington's extension which is sufficiently explained in Figs. 623, 25.

G. Davis Incision ("Annals of Surg.," Jan., 1906).—Locate the outer the right rectus at the level of the anterior superior spine. Make se incision through the skin 1½ inches long, having the edge of the its mid-point (Fig. 626). Divide the aponeurosis of the external liquely to the direction of its fibres, but directly in the line of the skin split, do not cut, the internal oblique and transversalis muscles. Open neum. Carry the cut inwards through the *anterior* layer of the

sheath of the rectus. Retract the rectus towards the middle line. Divide the *posterior* layer of rectus sheath along with the peritoneum.

If more room is required, prolong the incision outwards towards or even to the anterior superior spine and, if requisite, inwards through the rectus sheath to within an inch of the median line.

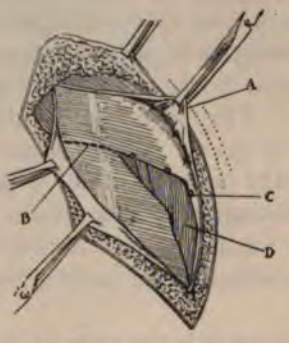


FIG. 623.—(*Shaw.*)

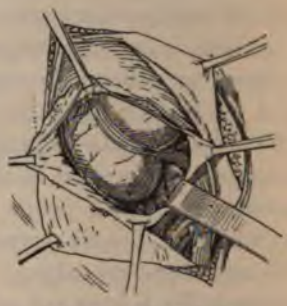


FIG. 624.—(*Shaw.*)

(C) *Rectus Incision.*—Locate the outer border of the right rectus. Beginning at a point one inch above a line joining the anterior superior spine to the umbilicus, make an incision downwards, about one-half inch internal and parallel to the edge of the rectus. The incision, 2½ inches in length, may be increased if necessary. Expose and split the anterior layer of rectus sheath. Split the rectus muscle *or* retract the muscle (Kammerer; Lennander; Battle;

FIG. 625.—(*Shaw.*)

Jaboulay) inwards to expose the posterior layer of sheath. Divide the posterior layer of rectus sheath and open the abdomen. This incision is good in almost all cases of appendicitis except when there is a large abscess present and located more or less externally. The wound may be closed in layers or by through-and-through sutures.

(D) *Incision through the linea semilunaris* requires no special description.

(E) *Oblique Incision.*—Locate the outer border of the right rectus muscle. Beginning at a point one inch above an imaginary line joining the anterior

superior iliac spine to the umbilicus, make an incision parallel to, and about ¾ of an inch external to, the edge of the right rectus muscle. This cut runs downwards and slightly inwards for about 3 inches. The fibres of the external oblique and its aponeurosis can be split longitudinally by blunt dissection; the deeper structures are divided in the direction of the wound. The usual

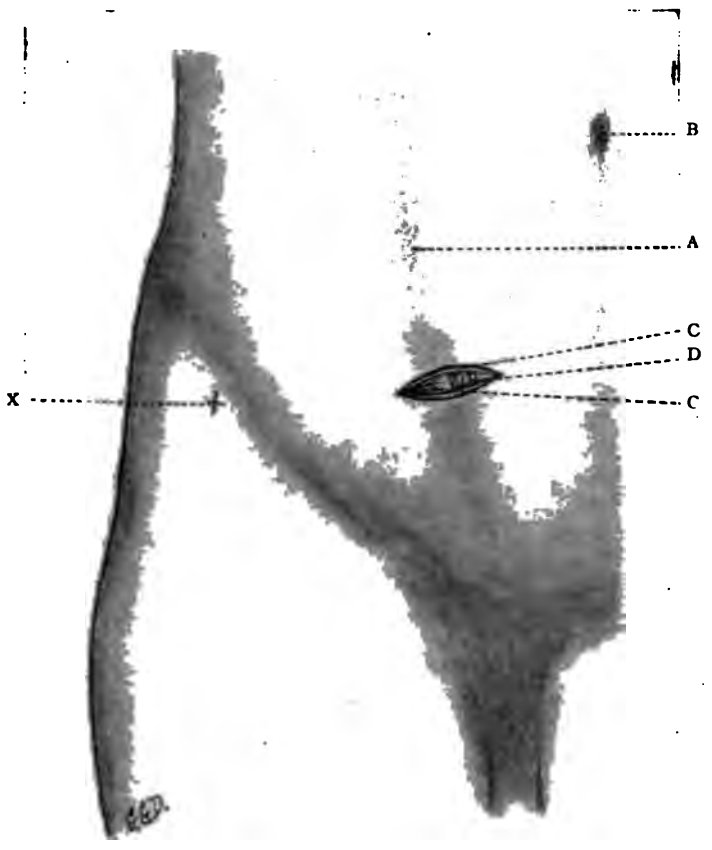


FIG. 626.—Davis' incision.

X. Ant. sup. spine. A. Ext. edge rectus. B. Umbilicus. C. Fascia of external oblique. D. Exposed rectus.

care must be exercised in opening the peritoneum. A good practical rule to adopt in operating is as follows: Make a 3-inch incision as above described down to the external oblique; make a small opening through the remainder of the belly-wall; introduce the forefinger to explore; if it is easy to complete the removal of the appendix through the small opening, do so; if not, enlarge the wound to the necessary extent. The size of the skin-wound is of little importance—the smaller the wound of the deep structures (of the *essential* belly-wall), the less danger will there be of hernia. The wound must be large

enough to permit of *easy* access to the field of work. After completing the appendicectomy, the wound may be closed in layers or by one layer of sutures traversing the whole thickness of the belly-wall.

(F) *Inferior or External Incision.*—From a point about two finger-breadths internal to the right anterior superior iliac spine and one inch above the line joining the umbilicus and the iliac spinous process make a 3-inch incision crossing the above line at right angles. Having made the skin-incision, follow the rules laid down for Method E.

(G) Through one of the previous incisions an abscess has been found but not opened. This abscess lies posteriorly and ought to be evacuated through the loin, *i.e.*, extraperitoneally. Guided by the finger in the belly make an incision directly over or, better, to the outer side of the abscess. After incising the parietes, but before opening into the abscess, close the exploratory wound, penetrate the abscess cavity, cleanse and drain it. In the same manner when large abscesses have been opened through the primary incision, one or more counter openings may be made to secure efficient drainage.

FIG. 627.—Ligation mesoappendix.

(H) In exceptional cases the primary opening may be made wherever the abscess tumor indicates, *e.g.*, the writer has opened an appendicial abscess in the *left* iliac region.

Step 2.—Search for and isolation of the appendix.

(A) Digital exploration. The forefinger or, if necessary, two fingers are introduced into the belly and the ascending colon is recognized. The finger follows the colon to the end of the cæcum and is systematically moved about its blind extremity, separating *gently* any adhesions which may be present and which interfere with the search. If the adhesions are firm or resist the gentle manipulations advised, then the next method to be described must be employed. The appendix may lie in any position near the end of the cæcum and may be either curled up on itself or extended. Having found the appendix, gently separate it from its surroundings and deliver it through the wound. The mesentery of the appendix is transfixed close to the appendix and colon, a ligature drawn through, the mesentery ligated and divided (Fig. 627). If the mesentery is voluminous, it may be necessary to apply two interlocked ligatures. When the meson is voluminous enough, Shaw's suture ligature gives perfect hemostasis and peritonealization. Fig. 628[1] shows how the suture is inserted while Fig. 628[2] shows how the cut edge of the meson is folded over when the two ends of the suture are pulled upon. When the suture is tied the meson is bunched together in pleats and hemostasis is assured. The digital exploration may be accomplished as follows: Pass the finger along the outer surface of the colon over the brim of the pelvis into the true pelvis. Feel for the pulsating iliac artery. Slip the finger upwards on the surface of the artery and

g the finger out of the true pelvis. If the finger is slightly hooked while g brought out of the pelvis it will bring up a loop of small intestine. This of small intestine is the ileum close to the cæcum and is within an inch of base of the vermiform appendix. The treatment of the appendix itself ngs to Step 3.

B) If it proves difficult to find and isolate the appendix by Method A, wound must be enlarged so that the eye may aid in the exploration. First gnize the ascending colon. This is easily done by noting its longitudinal :ular bands. Follow the anterior muscular band downwards; it leads :tly to the base of the appendix.* The isolation of the appendix may ccomplished in two ways: If one readily finds its distal end, one begins ting there and works towards the base. Any rigid adhesions should be

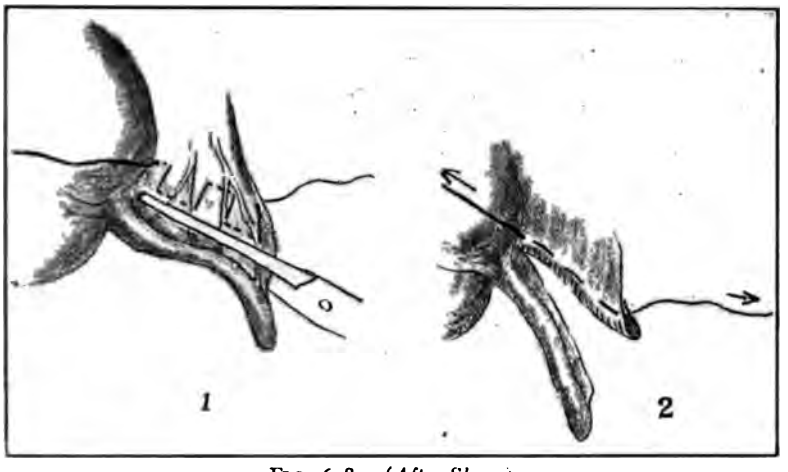


FIG. 628.—(*After Shaw.*)

ed with fine silk or catgut and divided. If adhesions to intestines are and short, one must remember a cardinal rule in abdominal surgery, viz., ifice part of what is being removed if non-malignant, rather than injure viscus. If necessary, a thin layer of the appendicular wall (never con- ing mucosa) may be left attached to a gut so as to avoid laceration of gut-wall. If it is difficult to find the distal extremity of the appendix, ıtion may be begun at its base. When the base of the appendix is isolated, ection may be much facilitated by passing a ligature through the mesen- olum (this ligature may be later used to ligate the organ or its meson). ction on the ligature brings the base of the appendix into the wound (Lili- al, Am. J. Surg., Ap. 1908). If there are many adhesions, after traction and ection have exposed more of the appendix, another traction ligature may

Kölliker remarks that if the appendix is much adherent it drags upon the longitudinal and as a consequence if the appendix is retrocæcal the drag makes the band curve with nvexity towards the middle line; if the appendix is median or if it lies in the pelvis the is curved with its convexity external. Occasionally anatomic anomalies puzzle the tor. They must be borne in mind. When the cæcum cannot be found in the right ossa, pick up the omentum and use it as a guide to the transverse colon; this little "dodge" been useful to the author. Transposition of viscera is a condition which must be nbered.

be passed through the mesenteriolum further along. This little "dodge" is of great aid and lessens handling of neighboring viscera. It is occasionally necessary to divide the appendix at its base before it can be removed. If this is necessary, one applies a clamp to or ties a ligature around the organ *distal* to the point of section and cauterizes the cut surface. This prevents contamination by the appendix while being isolated and while its cæcal extremity or stump is being treated. Under such circumstances Step 3 is proceeded with before the appendix itself is removed.

Not infrequently the longitudinal muscular band of the colon passes over the end of the cæcum and disappears at the reflection of the cæcal peritoneum to the parietes, and no appendix is visible. In such a case the appendix is retroperitoneal and retrocæcal. It may be discovered as follows: Pull the cæcum towards the middle line. Incise the parietal peritoneum immediately external and parallel to the cæcum. Introduce the finger into the newly made peritoneal wound and insinuate it behind the cæcum so as to mobilize that gut, raising it from its bed. This exposes the appendix which must be shelled out of its lair. It has no meson in this situation. Attend to the stump as in Step 3, Method A.

Remarks.—For some years it was the ambition of many surgeons to remove the appendix through an extremely small incision, but recognition of the fact that many other conditions may symptomatically resemble appendicitis calls for thorough abdominal exploration through a reasonably large cut. Healthy appendices have been on innumerable occasions called "clubbed" and accused of crimes of which they were entirely innocent. It is true that their removal often *accidentally* relieved the conditions causing the symptoms, but often failure resulted when larger exposure would have demonstrated the real disturber of the abdominal peace.

Step 3.—Treatment of the stump.

Method A.—Tie a ligature tightly around the appendix close to the cæcum. Before ligating it is best to crush the base of the appendix with a strong clamp and then to place the ligature in the groove left by the clamp. Cut away the appendix about one-fourth of an inch beyond the ligature. Thoroughly cauterize the lumen of the stump with liquid carbolic acid. Wipe away the carbolic acid with alcohol. This method is simple and gives excellent results. The main objection to the above is that the ligature may possibly be applied beyond a stricture of the appendix, and so there may be recurrence of the disease in the stump.

Method B avoids the disadvantage pertaining to the preceding method (McBurney). The appendix is divided one-fourth inch from the colon, the edges of the stump are seized with forceps, a probe is passed through its lumen into the colon, its mucous membrane is destroyed by the application either of liquid carbolic acid or the fine point of a cautery. Only after the mucous membrane is destroyed does one apply a ligature around the stump close to the colon. This is a thoroughly reliable and simple method. To eliminate the raw surfaces left by this method George Gray sutures the stump of the meso-appendix to that of the appendix itself (Fig. 629).

Method C.—At a point about one-fourth of an inch from the colon a circular incision is made through the serous coat of the appendix, leaving the muscular and mucous coats intact. The serous coat is separated from the muscular up to the colon. Close to the colon a ligature is tied around the tube, composed of muscularis and mucosa, and the appendix removed. The serous cuff is brought forwards over the stump and there sutured (Figs. 630, 631, 632). The method is safe, but cumbrous and unnecessary.

FIG. 629.—Gray's treatment of stump.

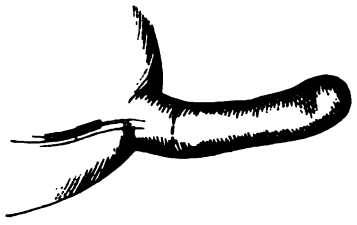


FIG. 630.

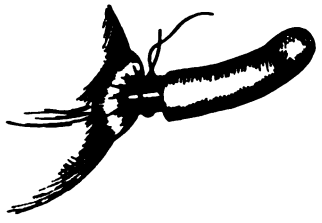


FIG. 631.

FIG. 632.

FIGS. 630, 631 AND 632.—Cuff method of treating stump.

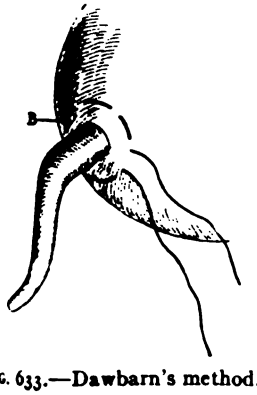


FIG. 633.—Dawbarn's method.

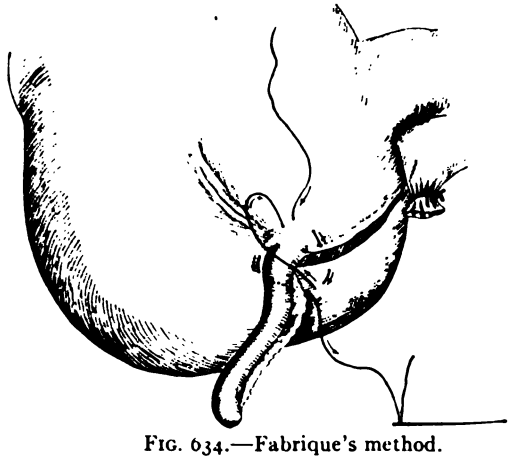


FIG. 634.—Fabrique's method.

Method D.—Cut away the appendix flush with the colon and treat the defect as a perforation of the gut—*i.e.*, sew up the hole that is left in the colon by a row of through-and-through sutures covered by a series of continuous Lembert sutures.

Method E.—Dawbarn applies a purse-string suture of fine silk or hemp through the serous and muscular coats of the colon around the base of the

appendix and about one-half inch distant from it (Fig. 633); cuts off the appendix; leaving a stump one-half inch in length; dilates the lumen of the stump; crushes the stump with a heavy forceps and the invaginates the stump into the colon, at the same time tightening and tying the purse-string suture.

To facilitate insertion Dawbarn suggests picking up a loop of the purse-string at B (Fig. 633); when this loop and the free ends of the thread are lifted up, inversion becomes easy.

Fig. 634 shows a better method of using the purse-string suture (Fabrique's method). The ends of the suture being on opposite sides of the wound permit better closure of the wound. Most surgeons ligate the base of the appendix before burying it as a number of cases of serious or even fatal hemorrhage into the intestine from the stump have been reported.

Method F.—This is a useful variant of Dawbarn's method. Introduce a purse-string suture as in Method E. Clamp the base of the appendix very firmly with a strong clamp. Cut away the appendix flush with the clamp and wipe the cut surface clean. Remove the clamp which has thoroughly crushed the included tissues. With a dissecting forceps grasp the stump and push it into the cæcum. Pull the purse-string suture tight and tie. The needle still remains attached to the purse-string suture; with it unite the stump of the mesoappendix of the cæcum at the point of invagination of the remnant of the appendix (Fig. 635).

FIG. 635.

Method G.—With forceps crush the base of the appendix. Apply a fine ligature to the groove made by the crushing forceps. Remove the appendix. Bury the stump by means of Gould's mattress suture.

Step 4.—If there has been no infection outside the appendix, sponge the field of operation with moist pads and close the wound without drainage.

The operation of appendicectomy by any of the methods described in the preceding paragraphs is suitable particularly in cases of chronic or recurrent disease and in those acute cases subjected to early operation before perforation, or before periappendicular suppuration has developed. Although when the abdomen is opened there is no expectation that pus will be met, yet the peritoneal cavity must always be protected by gauze pads while the appendix is being delivered and removed. The young operator is very apt to be afraid to boldly pull the cæcum (when it is not bound down by adhesions) out of the abdomen while he operates upon the appendix. It does no harm to pull out the cæcum where this is possible, but facilitates the work and renders it safer, besides avoiding a great deal of unnecessary trauma to neighboring intestines which gives rise to much post-operative pain. The whole operation of appendicectomy ought, if possible, to be carried out external to the belly cavity.

Operation in Acute Suppurative Appendicitis without Large Abscess.—The operation is very similar to that for recurrent disease.

Step 1.—Incision C, D, E (page 466).

Step 2.—Method B (page 469) is advisable, as the aid of the eye is most valuable. During the manipulations necessary for the discovery and isolation of the appendix, the general peritoneal cavity must be protected by pads of gauze placed inside the belly-walls, around the field of operation, unless the introduction of the pads would spread the infection which is already present. With the same object, to wit, peritoneal protection, it is wise to avoid the separation of any adhesions which might give protection and yet do not interfere with access to the appendix. While isolating the appendix and breaking down adhesions larger or smaller pockets of pus may be encountered. The contents of such must be carefully removed by sponging before further progress is attempted. The appendix, having been recognized and isolated, is found to be acutely inflamed, generally rigid, often rotten, and sometimes perforated or gangrenous. It must be removed. Its stump must be treated either by Methods A or B or by Method D (page 471). Method D is chosen if the stump is too soft and friable to hold a ligature. The appendix being out of the way, a gentle search is made for other pockets of pus; if such are found, they are treated as already described. If the appendix is retro-cæcal it may be reached as described in Step 2. Remember that retro-cæcal pus is liable to burrow upwards behind the colon and liver as well as towards the pelvis, and that it is often best drained by a tube passed through a stab wound at the outer margin of the lumbar mass of muscles. The whole field of operation is most carefully cleansed with sponges soaked in normal salt solution. The protective pads surrounding the field of work are removed and a split rubber tube or a cigarette drain is passed down to the bottom of the abscess cavity. The drain may be brought out through a stab wound and the original wound closed completely. Occasionally instead of using tubular or cigarette drains the whole infected area may be *loosely* filled with strips of plain or iodoform gauze the ends of which come out at the wound. As much of the abdominal wound as is not required to provide for drainage and future access to the field of contamination is sutured with silkworm-gut. Very abundant aseptic dressings are applied. The outer dressings will generally be found soaked with discharge within twelve hours and must then be changed.

Operation in Appendicitis with Large Localized Abscess.—Access to the abscess is usually obtained by Method F, G or H (page 468). The external incision is especially good because the pus must generally be sought to the outer side of the cæcum. When cutting through the parietes, œdema of the tissues may be noticed. If any part of the wound shows more evidence of œdema than another, one may be sure that pus is not far distant, and that the œdematous tissues will act as a guide to it. When the abscess is reached it must be opened with great care. For this purpose blunt dissection or scratching with a director is safe. The danger of opening some adherent intestine must not be forgotten. A small opening having been made into the abscess, it is enlarged by blunt force. Enlarging the opening into the abscess by means

of cutting with scissors or knife is improper if it can be avoided. Many careful surgeons end the operation at this stage, contenting themselves with the introduction of a drainage-tube and perhaps some gauze packing. They apply generous dressings which are soon soaked with discharge and must be changed. The practice is safe. Other surgeons explore the abscess cavity with the finger so as to remove any fæcal concretions or find the appendix. Often the appendix has sloughed and lies free in the pus. *Great care must be taken to avoid breaking down any protecting adhesions*, otherwise the general peritoneum may become infected. If the appendix is found attached to the cæcum and can be isolated without too great danger, it should be removed and its stump treated as already described. If it cannot be found without prolonged search, or if its isolation would endanger the integrity of the wall of adhesions protecting the peritoneal cavity, most surgeons let it alone. A few operators insist that the appendix should always be removed, but to the writer this appears an eminently unsafe doctrine. The abscess cavity is gently but thoroughly wiped with gauze moistened in warm salt solution, and loosely packed with iodoform gauze, which may surround a rubber drainage-tube. Frequently a sponge stick may be passed from the abscess into the true pelvis, where another pocket of pus may be found. Remember that infection may pass up the ascending colon and give rise to subhepatic, subphrenic, or even pleural suppuration. Abundant external dressings are applied. The after-treatment is the same as that required for any other abscess. To the inexperienced it is astonishing at times to see the amount of pus obtained in such cases when there has been, as is commonly the case, no fluctuation and the tumor has been small. Cases such as have been described very frequently heal slowly, and most stubborn sinuses may persist and require subsequent operation. When healing takes place, the scars are not very resistant to pressure, hence post-operative herniæ are not uncommon.

If the appendix has not been removed when the abscess was opened, it ought to be sought and extirpated after recovery has been obtained. This secondary operation gives an opportunity to repair any hernia which may be present. It has been stated dogmatically that the appendix is absolutely destroyed in the vast majority of cases in which abscess has formed. Morison, however, finds that in 90 per cent. of instances the appendix is not destroyed but soon recovers after its contents have been discharged by sloughing or perforation.

The foregoing description of operation when large abscess is present presupposes the possibility of gaining access to the abscess without opening the peritoneal cavity. Frequently an abscess forms, is surrounded by adherent intestines, omentum, and a great mass of exudate, but is at no point adherent to the anterior parietes. To gain access to the *tumor* it is necessary to open the peritoneal cavity and the pus must be evacuated by the transperitoneal route. In such cases the abdomen is opened directly over the tumor; the relations of the tumor are discovered by the finger used with the utmost delicacy; the peritoneal cavity is most carefully and thoroughly protected by pads of gauze; a line of cleavage is found in the tumor and the finger is made to enter the abscess cavity. The opening into the abscess should not be made large

first or the whole wound and packing will be flooded by pus. It is desirable at the pus escape so slowly that it can be wiped away at once with gauze. fter most of the pus has been removed, the opening into the abscess may be nlarged and the interior cleaned as well as possible with moist gauze. If he appendix is easily found, it should be removed. Now, the abscess may be rained by a tube or loose gauze packing.

Operation for General Peritonitis Secondary to Appendicitis.—The object f operation is to prevent further leakage of septic material into the perito- eum, to remove as much as possible of the septic material already present, nd to provide for drainage. The patients are suffering not merely from in- lammation but from shock and intense intoxication.

The Operation.—Make a large incision in the right inguinal region over the eat of the appendix. Remove the appendix. Frequently the inflammation as been so acute that no adhesions are present; if there are any, they should be roken down to permit of more thorough flushing. With wet sponges mop away ll foreign material, such as fæcal concretions, etc., which may be found in he peritoneal cavity. Systematically douche the peritoneum with a large tream of hot normal salt solution. The solution should be of such a heat that he hand can be kept immersed in it without discomfort (118° F.). The solu- ion may be poured from a pitcher, but it is better to conduct it by means of rge tubing to the furthest recesses of the abdomen, so that the flow of con- aminated solution may be outwards. When the solution returns clean, the bdominal subcavities—*e.g.*, Douglas's cul-de-sac and the subrenal cavities— re to be gently mopped dry with gauze pads. Drainage is provided for by lass or rubber tubes leading to Douglas's pouch. Abundant aseptic dressings nust be applied. The external dressings will be found soaked with discharge n a few hours and must be changed. If a glass tube has been used, it must be spirated at intervals of a few hours and removed generally in thirty-six to forty-eight hours.

Joseph A. Blake ("Transactions Am. Surg. Association," 1903) advocates early operation; lavage of the peritoneum with large quantities of saline solu- tion; closure of the peritoneal cavity *without* drainage, unless the latter is abso- lutely indicated by the presence of non-absorbable amounts of necrotic material. Blake's published results are remarkably good.

One of the gravest dangers in generalized peritonitis is the absorption of toxins into the circulation. The peritoneum of the upper part of the abdo- men has greater absorbing power than that of the lower, hence to let gravity aid in drainage and to hinder absorption as much as possible, Fowler recom- mends that patients be kept in an inclined position, the upper end of the bed being raised. The principle of this is admirable and good results have followed its use by most surgeons.

A method of operating followed by some surgeons in cases of early general- ized peritonitis is to open the abdomen in or near the middle line. Guided by the hand inside the abdomen it is easy to make an opening about 1½ inches in length in each inguinal region and through these insert split rubber tubes con- taining strands of iodoform gauze. Rapidly cleanse the abdomen with salt solution and close the median wound. Return the patient to bed and keep him

propped by bed-rest and pillows in a greatly exaggerated Fowler position. The results obtained are said to be excellent.

Le Conte ("Annals of Surg.," February, 1906), struck by the superiority of the results obtained by Murphy over those in his own very efficient hands, has adopted practically *in toto* the methods of the Chicago surgeon when dealing with diffuse septic peritonitis. The essentials of the technic are:

1. Rapid elimination of the cause of the peritonitis (gangrenous appendix, rupture of gut, rupture of pus tube, etc.). This with the *least possible handling* of the viscera.

2. Tubular drainage of the lowest portion of pelvis through a suprapubic opening and free drainage through the operative incision.

3. Elimination of all time-consuming procedures at the time of operating. Do *not* attempt to clean the peritoneum by mopping or flushing.

4. Fowler's position after operation.

5. Absorption of large quantities of salt solution through the rectum. This reverses the current in the lymphatics of the peritoneum, making the surface of that membrane a secreting instead of an absorbing one and this also

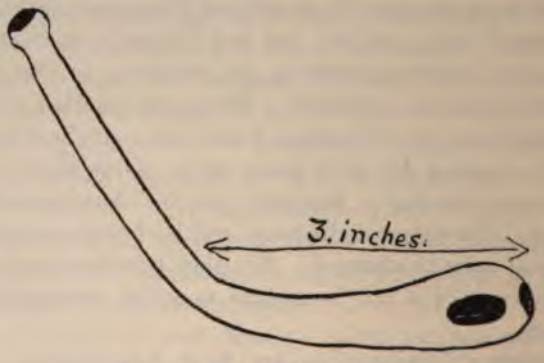


FIG. 636.—Murphy's nozzle.

increases the secretion of urine. Method of introducing the water into the rectum: Insert a nozzle *containing three or four openings*, into the anus. Attach tubing of fountain syringe to nozzle. Fill bag of syringe with water and elevate it a few inches above plane of rectum, in fact only high enough to let the water *slowly trickle* into the rectum at the rate of about one pint per hour. Do not permit fluid to accumulate in the bowel, just introduce the water at the rate at which it is absorbed. Do *not* in any way interfere with the caliber of the tubing (this should be fairly large). It is very important that there should be a free exchange of fluid between the gut and the water reservoir. The level of the water in the reservoir should only be high enough so that the water in the rectum merely covers the end of the anal tube. If the intrarectal pressure increases (due to gas, etc.) the water in the rectum is pressed back into the reservoir, the gas, etc., escapes, and as soon as the pressure is relieved the water flows back into the rectum. Much ingenuity has been expended in devising means to regulate the flow of water into the rectum and to utterly spoil the simplicity and value of the Murphy method.

6. Prevent peristalsis by withholding all food or liquids by the mouth. Opium is objectionable but may be required.

Most surgeons who have themselves undergone an abdominal operatio are liberal in their interpretation of the indications for giving opiates. Their personal experience with its humanitarian result is supported by Crile's obser-vation on the valuable effect of Morphine in sepsis.

H. F. Waterhouse (Lancet, Feb. 5, 1915), in acute peritonitis of almost any origin, advocates the local use of ether. (In this he follows Morestin). After opening the abdomen and treating the initial lesion, pass a rubber drain into the pelvis. This drain must have two lateral openings near its pelvic end. Close the wound snugly around the drain. Through a funnel pour 2 to 3 oz. of ether into the abdomen by means of the tube. Clamp the outer end of the tube. After about 3 hours the clamp may be removed.

Out of 59 cases of peritonitis treated as above there were but two deaths.

In all cases of appendicitis (24) the pulse rate was above 100; in several it was 120–140; many of them were examples of perforated or gangrenous appendicitis.

Johnson in 1906 (Crisler and Johnson, Southern Med. J., March, 1913) began treating acute peritonitis by pouring into the abdomen, an alcoholic solution of iodine (2½ to 3 per cent.). Usually a quart of the solution is used—sometimes a gallon. The amount does not matter so long as it penetrates every infected part of the abdomen. The result reported by Crisler and Johnson are remarkably good. Fort (Am. Journ. of Surg., Feb., 1915) strongly indorses the iodine treatment.

When ought one to advise operation in appendicitis?

Many surgeons answer the above question in a most simple manner by saying, "When appendicitis is diagnosed then is the time to operate." Most surgeons are less radical. All surgeons approve of operating in the interval between attacks of chronic or relapsing appendicitis. In acute appendicitis all surgeons approve of operating while it is reasonable to suppose that the infection is confined within the appendix itself—*i.e.*, within thirty-six or even forty-eight hours of the beginning of the attack, *but the earlier the better*. All are agreed on the necessity of evacuating abscesses when symptoms of absorp-tion are grave or increasing. In all other cases marked differences of opinion exist. The author's personal views are as follows, and are those common to many other operators.

1. If possible, operate within forty-eight hours of the inception of the dis-ease. Within twenty-four hours is better than forty-eight, and within twelve hours is better than twenty-four. *The earlier the better.*

2. After the lapse of forty-eight hours it is safer to adopt Ochsner's plan of non-operative treatment. (Ochsner, "Clinical Surgery.") This consists in —(*a*) Rest in bed. (*b*) Avoidance of purgatives. (*c*) Absolute denial of food and drink to the stomach. (*d*) If nausea or pain is present, lavage of the stom-ach. To nervous patients give morph. gr. ⅙ hypodermatically half an hour prior to lavage and spray or swab the pharynx with a local anesthetic. The patient should be in the lateral decubitus. (*e*) Exclusive rectal alimentation

(one ounce of concentrated predigested food in three ounces of salt solution, every four hours).

The exceptions to this rule are cases in young children and in the aged. The former cannot give assistance necessary; stomach lavage in them means a fight and consequently much danger from spread of infection. Further, the omentum in children is small and can do little to wall off the focus of infection. The aged bear confinement in bed badly and as a rule the whole treatment outlined is inapplicable to them. In these cases the surgeon should either operate at once or watch the case carefully and if improvement does not set in *promptly* or if the symptoms get worse, he should operate.

3. After the subsidence of the acute attack, where the temperature and pulse have become normal, when pain, tenderness, and muscular rigidity have disappeared and the bowels are acting well, without causing disturbance, then the interval operation ought to be performed. Many surgeons advise that a certain *definite* time be allowed to elapse between the attack and the interval operation, *e.g.*, four weeks, to permit of complete restitution of the normal conditions. This is a safe precaution, but a careful observer is able to form an opinion of his patient's condition and operate when he thinks right without adhering to any such strict rule as to lapse of time.

4. When the case is seen too late for the early operation, and tumor is present and the pulse, temperature, and general condition of the patient indicate a dangerous amount of absorption; if the tumor is increasing markedly and there are signs of the infection spreading, no surgeon would hesitate as to operation. Interference is imperative. When, however, the tumor is not increasing or is decreasing and the temperature and pulse are moderate and in proper relation to each other, there is, on the whole, less danger in delay than in immediate operation. Such cases almost always improve under the Ochsner regimen to such an extent that a safe interval operation becomes possible. The most rigid adherence to the regimen and to rest is essential, otherwise a catastrophe may happen. The danger of immediate operation is not merely that of shock and of general peritoneal infection, but the manipulations necessary for the evacuation of the encapsulated pus inevitably open by channels by which toxins are absorbed in quantities which may be fatal. Nature, when aided by rest, can safely encapsulate, and ultimately remove, even considerable quantities of pus in the peritoneum. If at any time during the course of the disease it becomes apparent that the encapsulation is incomplete and that dangerous amounts of toxins are being thrown into the circulation, then immediate operation becomes imperative. The author is perfectly aware that this advice violates the great law "*ubi pus ibi evacuo*," and will not meet with the approval of the majority of surgeons, but its importance has been impressed on him by experience.

5. In cases of appendicitis with generalized peritonitis the general rule is to operate at once and thoroughly. Very excellent results have been obtained in this way by many thoroughly reliable surgeons. The author is compelled to admit that his recoveries have been few in the cases on which he has operated under these conditions, while of the cases which refused operation a considerable number (too many to be all examples of mistaken diagnosis) have recovered most unexpectedly. Since adopting the Fowler or, better, the exaggerated

wler position during after-treatment, the writer's results have improved mensely.

Remarks.—(The following remarks seem to the author logical but must be ken "with a grain of salt" as the whole subject discussed is at present in a state t remote from chaos.) On page 470 a reasonably large incision is strongly ivised in operations for chronic appendicitis because the symptoms are so often ue to other troubles unrelated to the appendix as evidenced by their persistence fter the appendix is removed. Some of the anatomical conditions which may e found and which ought to attract the surgeon's attention are as follows:

1. Cæcum mobile with the neighboring ileum also mobile. This is perfectly ormal and causes no trouble unless volvulus should develop as it may in the imilarly mobile sigmoid loop.

2. Cæcum fixed; ileum mobile. Normal.

3. Cæcum mobile; ileum fixed by adhesions or by an ileo-pelvic band (Lane's leal kink). There may be intermittent or partial intestinal obstruction. Treatment: (a) Mobilization of the ileum by division of the band and repair of the resulting wound in the peritoneum; (b) cæcopexy; (c) ileal mobilization plus cæcopexy; (d) ileo-sigmoidostomy (Lane).

4. Cæcum fixed; ileum fixed, the ileum between its point of fixation and the cum is angulated. There may be partial or intermittent obstruction. reatment: (a) Mobilize ileum; (b) ileo-sigmoidostomy (Lane.)

5. Cæcum mobile; ileum fixed; band across the ascending colon. Inter- ittent obstruction possible but unlikely. Treatment if required: Mobilize um; cæcopexy after placing the cæcum in proper relation to the ascending lon and the ileum.

6. Cæcum mobile and sunk down into true pelvis. Ileo-transversostomy Vilms).

7. Cæcum mobile, much distended and atonic. Ileo-transversostomy Vilms). Cæcoplication plus cæcopexy (Roeder).

8. Cæcum mobile; ileum mobile; band across ascending colon (Jackson's embrane). Possible obstruction by cæcum bending over the band or being ushed over it, *e.g.*, by pregnant uterus (?) (Fromme). Treatment if required: ivision of the band or cæcopexy (Travel).

9. Band over ascending colon causing obstruction by compression. Treat- ent: Divide membrane or "dodge" the obstruction by ileo-transversostomy r ileo-sigmoidostomy.

10. Kinking at hepatic or splenic flexures with union of the ascending or descending colon to the corresponding portions of the transverse colon. Partial r intermittent obstruction. Treatment if necessary—short circuit by suitable anastomosis, *e.g.*, ileo-sigmoidostomy.

11. Kinking by so-called meso-sigmoiditis or deposits of scar tissue on the external surface of the meso-sigmoid, may give rise to volvulus requiring resec- tion of the involved gut or anastomosis between the afferent and efferent loops. After ileo-sigmoidostomy Lane thinks a "kink" above the site of anastomosis is valuable in preventing reflux of fæces into the descending colon and he some- times creates such a kink by sutures.

12. No anatomic conditions may be found to account for the symptoms

which may be due to faulty habits of life leading to auto-intoxication with its sequelæ. For such patients medical treatment alone is indicated unless such treatment may be aided by flushing the colon by means of cæcostomy or appendicostomy or possibly by Lane's ileo-sigmoidostomy.

TUBERCULOUS PERITONITIS

When tuberculous peritonitis is not a mere phase in the history of a general tuberculosis, it is usually a reaction against infection coming from a tuberculous Fallopian tube; from a tuberculous stenosing ulcer of the ileum; from a tuberculous tumor of the ileum and cæcum; from a tuberculous vermiform appendix. Tuberculous peritonitis is much more common in the female, as the Fallopian tubes are the favorite sites for primary intraabdominal lesions.

Accidentally it was found that mere abdominal incision and evacuation of any ascitic fluid present, with or without subsequent drainage, led to recovery in many cases. Veit believes that 50 per cent. of the cases are cured and 25 per cent. improved after the above treatment, the curative agent being serum effused as a result of the operative interference, acting as an antitoxin.

The most favorable cases are those in which ascitic fluid was *removed* during the operation, hence it is difficult to imagine the above theory correct. J. B. Murphy observed that where the end of the diseased Fallopian tube was patent, peritonitis was progressive, and where the ostium was closed by adhesions, etc., the peritonitis became stationary or was cured. Mayo came to the conclusion that in the presence of ascites the fimbriated extremity of the tube was mechanically kept patent, the fimbriæ being kept from adhering to each other and to neighboring structures, and hence the infective contents of the tube could constantly or intermittently leak into the peritoneal cavity. This gives a feasible explanation as to why simple laparotomy with removal of ascitic fluid often results in the cure of tuberculous peritonitis; the end of the tube, no longer buoyed up by the fluid, becomes closed, either by the fimbriæ adhering to each other or to neighboring structures. The primary lesion thus becomes encapsulated, and the peritoneum, being very resistant to tuberculosis, recovers. It has long been known that the cases accompanied by ascites are the ones most benefited by surgical interference.

Primary tuberculous lesions in the ileum have a great tendency towards spontaneous recovery; in these, when operation is demanded, it is to overcome resultant stenosis.

The tumor-like tuberculosis of the ileo-cæcal region has likewise a predisposition to cure. Both in the case of disease of the ileum and of the ileo-cæcal region the presence of ascites is well calculated to prevent the formation of protective adhesions around the focus of disease, hence the simple removal of the fluid may result in efficient encapsulation of the primary focus.

Baisch ("Munch. med. Woch.," 20 Aug., 1907) reports the results in one hundred and ten cases of tuberculous peritonitis observed from four to ten years in the Tübingan gynecological clinic.

1. **Pure Exudative Form.**—Thirty-eight cases; thirty-four submitted to operation, twenty-two cured, twelve of those operated on died in from three months to four years.

2. **Dry Adhesive Form.**—Twenty-two cases; eleven submitted to operation, eight of whom remained well, a few of these recovered only after a long illness and two had fæcal fistula which closed after some months.

3. **Tuberculous Adnexæ.**—Forty-five cases; thirty-two submitted to operation with good results (eighteen cured; five in which one tube was left required a secondary operation). Do not leave an apparently healthy Fallopian tube. Leave the uterus and if an ovary appears healthy it may safely be left.

Operative Treatment.—It is presumed that the diagnosis of tuberculous peritonitis has been made, but the site of the primary lesion is unknown.

Step 1.—Open the abdomen, in the female, by median, in the male, by the right rectus, incision. Evacuate any fluid which may be present.

Step 2.—If in the female, examine the Fallopian tubes. This must be done with enormous caution in the presence of many adhesions, as it is easy to tear into a gut. If the necessary manipulations are very difficult, the dangers from injury to the gut outweigh the advantages of a radical removal of the primary focus, and it will be wise for most surgeons to trust to the encapsulation of the disease which is likely to result.

If safe, removal of the tubes is of course the procedure of choice. In any case examine the favorite sites of tuberculous lesions. Remember that what may appear a simple chronic appendicitis may be tuberculous, and that with the appendix any enlarged glands in the mesenteriolum ought to be removed. When there is a stenosing ulcer of the ileum, an anastomosis between the afferent and efferent segments of gut is all that is commonly required. If the diseased segment of gut is limited in extent and easily excised, its removal is proper, though not imperative.

The tumor-like tuberculous lesion of the ileo-cæcal region ought to be excised if this is fairly easy; if difficult, then that segment of the gut may be "segregated" or left to the curative powers of nature, assisted by the abdominal incision.

M. H. Richardson writes: "When, therefore, I have found a tuberculosis limited to a single coil of intestine, rather than excise that coil, except when stricture is present, I have contented myself with the exploration and demonstration of the disease. If the area affected has been one that could be easily and safely removed, I have removed it, as in tuberculosis limited to the appendix or to the Fallopian tubes."

In one case operated on by the author three enlarged lymph nodes, one the size of a hen egg, existed in the mesentery of the ileum. There was no evident disease of the gut. Incision through the superficial layer of the mesentry permitted the easy enucleation of the diseased structures, after which the mesenteric wound was sutured. Recovery.

Any tuberculous abscesses encountered should be evacuated, dried, iodoformized, and *not* drained.

The end results after enterectomy by Goullioud for ileo-cæcal tuberculosis were published by Perreve (These de Lyons 1919–1920, Ref. La Pr. Med. June 9, 1920). Of 15 patients followed, 10 were cured. Three for 17 years, 1 for 16 years, 2 for 10 years, 1 seven years, 3 from 2 to 5 years. Among the 5 deaths following operation there was active tuberculosis, death occurring some months after operation from

pulmonary or meningitic tuberculosis. Two other patients survived 9 years, one dying from obscure gastric disturbance, the other from acute peritonitis following a secondary enterectomy.

Step 3.—Close the abdomen, preferably without drainage. The use of a drain is liable to lead to secondary infection and fæcal fistula.

CHAPTER XXXVI

THE RECTUM

Imperforate Anus.—There are two forms of imperforate anus, (A) No anal depression is present; (B) an anal depression is present, but does not open into the rectum.

(A) The anal depression is absent.

The Operation.—Place the child in the lithotomy position. Draw off the urine with a catheter. Do *not* keep the patient *deeply* anesthetized, as its attempts at crying and struggling press the gut downwards and aid the surgeon in recognizing the gut when he approaches it. Of course, enough anesthetic should be given to prevent suffering.

Step 1.—Make an incision in the median line from the middle of the perineum to the tip of the coccyx. Penetrate the skin and the musculo-aponeurotic floor of the pelvis. Frequently the gut will now present and be recognized from the dark blue color given it by the contained meconium. If the gut is not found, retract the walls of the wound. Note the position of the bladder—if necessary, introducing a sound into the bladder for this purpose. Deepen the wound by blunt dissection, following the concavity of the sacrum to its promontory. If the external wound is too small to permit of such deep dissection, continue the original incision backwards over the lower end of the sacrum and excise the coccyx and lowest segment of the sacrum. When the neighborhood of the gut is reached, if the child cries, an impulse will be communicated to the palpating finger. If the child is too deeply anesthetized to cry, intermittent firm pressure on the abdomen may give the same result. The gut having been found, separate its lower end as freely as possible from its surroundings.

Step 2.—When the gut is found to be superficial, seize it with a couple of small volsellæ or pass a suture through it for purposes of traction and pull it downwards to the skin, separating its lateral adhesions as traction is being made. With a knife cut into the gut. Meconium at once escapes and must be washed away by a stream of warm water. Clean out the gut by means of injections of warm water until the water returns clear. Cleanse the wound with a mild antiseptic solution.

Step 3.—Carefully and accurately suture the opening in the gut to the skin with interrupted sutures. Close the remainder of the wound with such deep and superficial sutures as may be required.

When the gut is more deeply situated, the technic is rendered much more difficult. It may be impossible to bring the gut down to the skin before evacuating its contents. In such a case, fix the gut with sharp hooks or forceps, open it with a knife, and by means of a catheter douche out its contents. When the

t has been emptied, it is often possible to separate it from its lateral connec-
ns and bring it down to or near to the skin. When possible, the edges of the
ening in the gut must be accurately sutured to the skin, as already
scribed.

Should the rectum be entirely absent, the peritoneal cavity may be opened
rough the perineal wound and the first loop of gut which presents (generally
e sigmoid) brought down, opened, and sutured to the skin (Stromeyer). In
ses of failure to find the lower end of the rectum through the perineal route
acleod recommends that the abdomen be opened, the lower end of the *blind*
ctum found, rendered mobile, and pushed downwards into the perineal wound,
here it is treated in the manner already described.

(B) The anal portion of the gut is present, but is not joined to the rectum.

By palpation and inspection find if there is only a thin diaphragm separating
e rectum from the anal gut or depression. If this is so, perforate or excise
e diaphragm. If, as is often the case, much tissue is interposed, make an
cision in the middle line from the anal depression or gut to the coccyx, deepen
e incision as may be required, and proceed as if no anal gut were present,
cept that after the rectum has been opened and evacuated, its opening should
sutured to the anal gut instead of to the skin.

When none of the methods described is successful, or if the condition of the
atient is such as to render the operation hazardous, it is proper to make a
rmanent or temporary artificial anus in the inguinal or lumbar region.
hould it seem advisable, the perineal operation may be attempted on a later date.

Prolapsus Recti.—Rectal prolapse may be of two forms: in one form the
ctal mucous membrane alone is protruded through the anus; in another,
e rectal walls are more or less prolapsed. The prolapsed tissue may be
ducible or irreducible; in the latter case it generally shows evidences of past
nd present inflammation. The prolapse may be due to atony or dilatation
f the sphincter, or to a lack of support to the gut from above. Relaxation of
he levator ani muscles seems to act by destroying the ano-rectal angle. Nor-
ally the rectum forms with the anus nearly a right angle opening downwards
nd backwards. When the levator ani muscles are deficient the upper (rectal)
rifice of the anal canal moves backwards while the inferior orifice moves for-
ards and it is easy for the rectum to push its way through the anus during
oughing or strain. Prolapse may be an accidental concomitant of a rectal
umor, the weight of the tumor dragging the gut down. Comparatively re-
ently the main active treatment of rectal prolapse consisted in chemical or
hermal destruction of protruding mucous membrane or of portions of the dilated
nus, the scar contraction incident to healing leading to narrowing of the anus
nd support of the gut. Strangulation of the protruding tissues by means of
gatures was also recommended and often gave good results. All such meas-
res ought to be discarded, as chemical and thermal action is difficult to regu-
te and the strangulation by ligature is distinctly dangerous.

There are three distinct principles, each of which is the base of a modern
ethod of operative treatment.

1. When the prolapse is due to sphincteric atony or looseness, the principle
treatment is to overcome this condition by narrowing the sphincter.

[illegible] the [illegible] angle, this [illegible]

[illegible] must [illegible] support must [illegible]

[illegible] the pro- [illegible] must be supplemented [illegible]

[illegible] and in children [illegible]

[illegible] —From the [illegible] a triangle of mucous membrane. The [illegible] the mouth. The apex is directed [illegible] a similar triangle having [illegible] the coccyx. [illegible] the former by the [illegible] the skin and [illegible] a wedge of the tissues ex- [illegible] the skin and mucous membrane. With the wedge [illegible] Insert deep and superficial [illegible] It is a wise precaution to unite the divided [illegible] interrupted horsehair sutures. In [illegible] I have performed the above operation [illegible] The operation must be done under the most [illegible] This is of great moment in all the plastic opera- [illegible]

II. [illegible] may be modified as follows: Make a curved transverse incision [illegible] more or less closely the muco-cutaneous junction at the posterior side of the anus. Through this incision, with scissors or knife dissect the mucous membrane from the posterior anal wall until a point is reached above the sphincter. Excise a sufficiency of the sphincter and with catgut sew the divided ends together. If necessary, excise a portion of the reflected flap of mucous membrane. Close the superficial wound. This operation is only feasible if the prolapse can be reduced.

Operation to Restore the Recto-anal Angle. Brechot's Operation (Paris Med., March 15, 1919). 1. From a point ¾ inch (2 cm.) above the tip of the coccyx make a median incision upwards for 4–5 in. (12 cm.). Expose the posterior surface of the coccyx and lower portion of the sacrum.

2. On each side of the sacrum make an opening through the great sacro-sciatic ligament. Through these openings denude the anterior surface of the sacrum to the necessary extent.

3. Divide the sacrum transversely at the level of the coccygeal cornua and at a point two finger-breadths higher up. Remove the segment of sacrum between the two lines of section.

4. Unite the lower segment of sacrum (and coccyx) to the upper segment by a wire or chromic gut suture and by suture of the lateral aponeurotic planes.

5. Close the wound.

Brechot's operation may be combined with myorrhaphy of the fibres of the [illegible]evatores ani in front of the anus.

Operations to Narrow the Rectal Lumen and thus Prevent Prolapse.—Lange's Operation (Transverse Rectorrhaphy).—Make an incision in the middle line from a point immediately behind the anus to the base of the coccyx. Do *not* injure the sphincter. Resect the coccyx. By dissection expose the posterior surface of the rectum. Introduce a number of sutures into the gut wall in the Lembert fashion, transversely, as if closing a longitudinal tear in the rectal wall. The sutures must *not* penetrate the mucosa. Tie the sutures. The result is to narrow the gut by throwing its posterior wall into a longitudinal fold. Close the external wound by deep and superficial sutures.

Rectopexy.—(A) *Mummery's Operation.*—Prepare the patient carefully as it is essential to insure against action of the bowels for at least four or five days after operation. Note the extent of the prolapse and return it. Thoroughly swab the lower rectum with spirit-soap and water. Douche with Lysol (1 drachm to the pint) and remove excess of solution with dry gauze. Clean the field of operation.

Step 1.—Midway between the tip of the coccyx and the anus make a two inch transverse incision. Deepen the incision, slightly backwards and divide the attachment of the external sphincter to the coccyx. Open the posterior rectal space. Guided by the finger enlarge the opening thoroughly to each side of the rectum and separate the bowel from the concavity of the sacrum. This can be done by blunt dissection aided by a few snips of the scissors. A gloved finger in the rectum serves as a useful guide. The dissection should be carried upwards for a distance about equal to the length of the prolapse when it was down, and ought to be carried round the sides of the rectum as well as up its posterior wall. When the prolapse is large and of long standing carry the separation into the space above the levator ani and between this muscle and the rectal wall on each side.

Step 2.—Pack the whole cavity with tapes of selvedged gauze (Bismuth or Iodoform) to prevent primary union, but the packing must *not* be tight enough to run any risk of causing pressure necrosis.

Step 3.—Just within the anus apply forceps to a fold of the mucous membrane of the anterior wall of the rectum. Replace the forceps by a ligature. This prevents any tendency to prolapse of this membrane into the patulous anus after the posterior wall has been fixed.

After Treatment.—Keep the patient flat in bed. Do not let him sit up for any purpose for about 30 days. After six days remove parts of the gauze day by day replacing them with light packing. After this dress daily until the wound is healed (not less than three weeks). The diet should be very light until the bowels are moved by oil enemata on the sixth or seventh day.

In Mummery's operation not only is a rectopexy secured but division of the attachments of the external sphincter to the coccyx allows the anus to move forward which in itself tends to prevent further prolapse. The author has found the operation excellent.

(B) *Verneuil's Operation.*—With a knife trace a triangle having its base at the anus, its apex at the tip of the coccyx. Excise this triangle of tissue and with it the whole segment of sphincter corresponding to its base. Pass a long suture transversely through the posterior wall of the exposed rectum, without

penetrating the mucosa. Arm each end of the suture with a needle. Push the needles through the tissues of the back, from within outwards, to emerge through the skin, one on each side of the sacrococcygeal articulation. At lower levels introduce three other sutures in a similar manner. Tie the sutures. This narrows the anus and pulls the lower rectum backwards and upwards.

(C) *Marchant's Operation.*—Expose the posterior surface of the rectum by means of a median incision from behind the anus to the tip of the coccyx. Introduce several rows of sutures in the long axis of the gut after the Lembert method, as if to close a series of transverse ruptures of the gut. The sutures must not penetrate the mucosa. As each row of longitudinally placed sutures is tied the posterior wall of the gut is thrown into a series of transverse folds, which shortens it. With catgut unite the lowermost fold to the tissues immediately in front of the coccyx. Give additional support by introducing one or more sutures after the method of Verneuil described above. Close the wound completely.

Colopexotomy (Jeannel's Operation).—The object of this operation is to attach the sigmoid flexure to the abdominal wall and so give superior support to the rectum. The scope of the operation must be limited. In Garrè's clinic 59 per cent. of relapses followed the operation or some modification of it. (Pachnio, "Beiträge z. klin. Chir.," xlv, 300.)

The Operation.—Open the belly as in left inguinal colostomy. Seize the sigmoid flexure and pull it up until the rectal prolapse is reduced. Suture to the abdominal wound the lowest portion of the gut which can conveniently be brought into it after reduction of the prolapse. Make an artificial anus. After the gut is securely attached to the abdominal wall, and the rectum, irritated and inflamed because of having been prolapsed, is healed, the artificial anus may be closed.

McArthur's Operation.—Abdominal rectopexy. Principles of operation: (1) Obliterate the dilatation of Douglas' pouch which is always present. (2) Perform a rectopexy by uniting the rectum to a fixed portion of the sigmoid. (3) Avoid dangers from recto-sigmoid kinking by making an anastomosis between the rectum and sigmoid. The anastomosis should be made with three lines of suture so as to assure unusually thorough union. (4) If necessary repair the pelvic floor, *e.g.*, by Marchant's method.

Step 1.—Trendelenburg position. Open the abdomen in the middle line below the umbilicus.

Step 2.—Seize the rectum and pull it upwards until the prolapse is completely reduced. Note that the lower part of the peritoneum of Douglas' pouch cannot be put on the stretch no matter how strongly one may pull up the gut. Obliterate the relaxed lower segment of Douglas' pouch by suturing its walls together. This is as important as obliterating the sac of a hernia.

Step 3.—To the upper portion of the rectum apply an intestinal clamp. Choose a portion of the upper sigmoid, or of the junction of the descending colon and the upper sigmoid, which is well fixed to the posterior abdominal wall (*i.e.*, which is well supported superiorly) and yet which can be easily brought into apposition with the chosen portion of rectum. Apply an intestinal clamp

here. Make a large lateral anastomosis between the chosen segments of rectum and sigmoid. Remove the clamps.

Step 4.—Close the abdomen. If necessary the anal opening may be narrowed at a subsequent operation.

Quénu and Duval ("Rev. de Chir.," Feb., 1910) describe a very elaborate means of obliterating Douglas' pouch; suturing the lower pelvic colon transversely to the back of the broad ligaments and vaginal dome (to the back of the bladder in the male); the upper part of the colon to the exposed tendon of the psoas parvus. Fig. 637 explains the operation.

Excision of the Prolapsed Gut.—A considerable number of methods have been devised for the removal of the prolapsed mass. Several of the methods

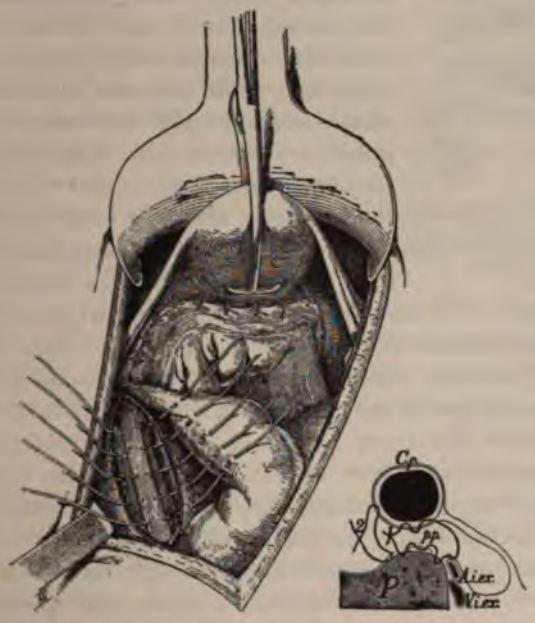


FIG. 637.—(*Quénu and Duval.*)

fail to recognize the existence of a peritoneal pouch between the inner and outer tube of the intussuscepted gut and that a loop of small intestine may be present in that pouch. This failure renders all such methods too dangerous to be justifiable, and they will not be here described. Excision should be reserved for gangrenous, irreducible or ulcerated cases as it has a death rate of 10 per cent. and there are at least 7 per cent. of recurrences.

Mikulicz's Operation.—Place the patient in the lithotomy position at the edge of the table. Make a horizontal incision through the anterior half of the external tube or cylinder of gut, *i.e.*, into the peritoneal pouch. Explore the pouch with the finger and reduce its contents if there are any. Suture, by the Lembert method, the peritoneal surface of the outer tube to that of the inner tube (Fig. 638). Cut away the gut corresponding and peripheral to the line of suture. Cover the line of suture by a row of stitches uniting the mucous membrane of the outer to that of the inner tube. The posterior half of the

prolapsed gut must now be attacked in the same manner and the outer and inner tubes united by a row of Lembert sutures protected from contamination by some stitches which involve the mucosa alone.

To be successful the above operation must often be supplemented by a plastic operation on the sphincter such as has already been described.

Stricture of Rectum.—I. When a rectal stricture is soft and can be reached through the anus, treatment by gradual dilatation should be attempted.

Introduction of Rectal Bougies.—Place the patient on his left side with the right thigh partially flexed. Introduce the index finger through the anus and locate the opening through the stricture. If the stricture is large enough to permit the passage of the finger without force being employed, the finger may be used as a bougie. If the stricture is either narrower or much wider than the finger, use the finger as a guide and pass a well-oiled soft-rubber rectal bougie through the constriction. *No appreciable force must be used.* Leave the bougie in place for two or three minutes and withdraw it. Repeat the operation after the lapse of from one to four days, *i.e.*, after any irritation produced by the operation has subsided. At each operation it may be necessary to pass several instruments of different sizes, the last one being the largest which it is possible to introduce through the constriction without force. The principle of treatment is identical with that of gradual dilatation of urethral stricture. As in the case of the urethra, some rectal strictures are too irritable to permit of gradual dilatation. When suitable, the treatment is safe, but it is only palliative, as the contraction recurs when dilatation is discontinued.

FIG. 638.—Prolapsus of rectum. O, T. Outer tube of gut. I. T. Inner tube of gut. P. Peritoneum. S. Sphincter ani. X. Suture.

II. *Credé's Operation.*—If the stricture is firm and resistant to gradual dilatation, Credé's operation may be useful. Administer an anesthetic. Guided by the finger, pass a probe-pointed knife through the stricture and with it make a number of small cuts or "*nicks*" in the protruding edge or ring of the stricture. Six or eight of these cuts may be made, none of them deep enough to endanger the peritoneum. Remove the knife and gently introduce a bougie. The rest of the treatment is that of gradual dilatation.

Forcible dilatation has been practised, but has proven too brutal and dangerous. It is unjustifiable.

III. *Posterior Rectotomy.*—Place the patient in the lithotomy position. Guided by the finger, pass a probe-pointed bistoury through the stricture and divide it completely in the middle line posteriorly. Continue the incision downwards and backwards so as to divide the sphincter ani. The result of this cut is the division of the stricture, the rectal wall below the stricture, and the sphincter, in the posterior median line. Attend to hemostasis. Pack the wound. The after-treatment consists in frequent changes of dressings, in careful cleansings, and subsequently in the use of rectal bougies.

IV. *Pean's Modification of Posterior Rectotomy.*—Make an incision in the middle line of the posterior wall of the rectum from a point three-fourths of an inch above the stricture to and including the sphincter Contani. inue the inci-

on backwards in the middle line until the incision through the skin equals in ngth that through the mucous membrane of the rectum. Pull the mucous embrane at the upper angle of the wound downwards and suture it to the in. To render the mucous membrane movable, it may be necessary to under- ine it slightly. The principle of the operation is to convert the original ver- cal wound into a transverse one and so gain room.

V. *Sonnenburg's Operation.*—Expose the gut by Kraske's method (page 491). ivide the stricture, vertically, taking care to avoid injuring the sphincter. ack the wound. Healing takes place very slowly; fistulæ are almost certain persist, and after-treatment with bougies is necessary.

VI. *Sokoloff's Operation.*—This operation is the same as Sonnenburg's, but stead of packing the wound, the vertical incision is converted into a transverse ne by means of sutures. In suitable cases this operation is one of much romise, but cases suitable for it must be exceedingly rare.

VII. *Excision of the Stricture.*—The stricture may be excised in various ays. The methods of rectal excision are described elsewhere. It was hoped at excision, though dangerous, might prove an entirely reliable means of eatment. Experience seems to show that it is little better than a means of alliation.

VIII. *Colo-rectostomy.*—When the stricture is seated high up in the rectum, n anastomosis may be made between the colon and the rectum so that the testinal contents may pass around the stricture.

IX. *Colostomy* may be used in the treatment of rectal stricture for two pur- oses: (*a*) To give relief from the obstruction; (*b*) to give rest to the rectum nd to permit of local operations or treatment being carried out without inter- ption from fæces. In this case after the rectal disease has been cured the rtificial anus may be closed.

The methods of performing colostomy are described elsewhere.

Excision of Rectum.—Excision of the rectum is most commonly indicated cases of malignant tumors. When performed for the relief of rectal stricture non-malignant), the operation is identical, except that in this case it is not ecessary to excise the disease so extensively.

Preliminary Treatment.—Two main indications must be observed, viz.: (1) mprove the general condition of the patient; (2) diminish the septicity of the testine.

The general condition may be improved by means of proper regulation of he organs of elimination and of proper regulation of the diet. A diet of eggs nd milk is highly to be recommended. How may the septicity of the gut be iminished? The only efficient medicinal means of cleansing the rectum is urgation. But it is easy to carry this means too far and weaken the patient. The moderate use of salines or of calomel is highly proper. For Tuttle's ethod of cleaning the rectum see page 515. Various antiseptics have been dministered by the mouth, in the hope of lessening the filthiness of the rectum resorcin, salol, etc.), but in the opinion of the writer such endeavors must be futile as an attempt to antisepticize the Mississippi River at New Orleans y pouring a barrel of corrosive sublimate into its current at St. Paul.

Apart from moderate purgation, the only possible means to approximate cleanliness in the lower bowel is flushing and scraping.

Flushing the Rectum.—Pass a long, soft, flexible rubber tube into the rectum and through the stricture. Through a funnel on the proximal end of the tube pour warm water or boracic acid solution into the gut until the patient experiences a feeling of discomfort. Lower the funnel and tube, and permit the water to flow into a receptacle on the floor. Repeat the operation. Carry out these rectal flushings every morning and evening for four or five days before the operation.

Scraping the Rectum.—Immediately before the operation dilate the anus and scrape away all the friable surface of the cancerous growth with a sharp spoon, preferably with a flushing curette. The bleeding is trivial and soon stops. Should the hemorrhage not cease spontaneously and quickly, touch the bleeding points with a thermo-cautery or with liquid carbolic acid, preferably the former. Removal of the abominably foul surface of the cancer with a curette and thorough flushing of the rectum are undoubtedly the best means of diminishing the septicity of the bowel, but however thoroughly these means are used, the cleanliness obtained is only relative, though none the less important.

I. *Vaginal Route.*—In the female, when the anterior rectal wall alone is diseased, one may make a vertical incision through the posterior vaginal wall, expose the growth, excise it, suture the opening left in the rectum, and then separately suture the vaginal wound. Such an operation is not often suitable.

II. *Anal Route.*—(A) The anus is involved in the disease. Place the patient in the lithotomy position. Make an incision all around the anus. With blunt and sharp dissection separate the diseased anus and the rectum from their surroundings until a point in the rectum is reached about one and one-half inches above the disease. Divide the rectum at this point and remove the disease. Attend to hemostasis. Pull the edge of the divided rectum downwards and suture it to the skin, if possible. If the incision surrounding the anus does not give sufficient room for the next steps of the operation, one may supplement it by a median incision running backwards to the coccyx or one may even excise the coccyx. If it is impossible to bring the divided end of the rectum down to the skin at the site of the natural anus, it may be sutured to the skin at the level of the coccyx.

The operation as described is permissible only if the anus is diseased. The sphincter is sacrificed. Incontinence of fæces results. Delbet writes: "To avoid these inconveniences Witzel, on the advice of Willems, passes the end of the rectum through the fibres of the gluteus maximus. Rydygier through the pyriformis and gluteus maximus. Gersuny, before fixing the rectum, so twists it on its axis that its longitudinal muscular fibres play the rôle of sphincter, or at least offer some mechanical opposition to the escape of intestinal contents."

(B) The anus is *not* involved in the disease.

1. The disease is freely movable and only involves a small part of the rectal wall. Place the patient in the lithotomy position. Dilate the anus fully. Seize the tumor with a volsella and pull it downward into a freely accessible position. On each side of and a little above the tumor seize the rectum with forceps or sharp hooks. The object of this is to prevent the wound being re-

cted out of easy reach after the tumor is removed. Freely excise the tumor. se the wound with sutures after attending to hemostasis. When possible, it wise to insert the sutures in the long axis of the gut so that the resulting scar transverse and danger of subsequent stricture is lessened.

2. The disease is freely movable, is *very low down* in the rectum, but involves or nearly all the circumference of the gut. Place the patient in the lithotomy sition. Dilate the anus fully. Seize the tumor with volsellæ and pull downwards into a freely accessible position. Make an incision completely ound the anus at the muco-cutaneous junction. Separate the anal mucous mbrane from the sphincter. When the upper edge of the sphincter is passed, vide the whole thickness of the rectal wall and separate the rectum from its rroundings until a point is reached well above the disease. In cancer remove much rather than too little. Attend to hemostasis. Divide the rectum ove the disease and remove it. Pull down the divided end of healthy rectum d suture it to the skin.

III. *The Perineal Route.*—Place the patient in the lithotomy position. ke an incision in the middle line from the anus to the point of the coccyx. is incision divides the sphincter. Dieffenbach supplements the above cut by placed in the middle line anteriorly which also divides the sphincter and ches to the bulb of the urethra. Retract the edges of the wound. Separate anal mucous membrane from the sphincter and proceed to remove the ease as described in the preceding paragraph. In dissecting the rectum free m its surroundings take special care not to injure the prostate or the base the bladder; for this purpose it is wise to do most of the dissection with the ger or some blunt instrument. Should the bladder be torn, its wound must be sed at once by a few sutures.

The disease having been removed, pull down the divided end of the healthy tum and suture it to the anal skin. Close the rest of the wound with deep d superficial sutures. The stitches should restore the integrity of the sphinc- and do away with the presence of dead spaces in the depth of the extensive und. If it is impossible to avoid the presence of dead spaces, such must be ined.

If, in order freely to excise the tumor it is necessary to open the peritoneum, so, but before penetrating that cavity carefully wash the wound with an *tiseptic* solution and close the peritoneal wound with sutures at as early a ge in the operation as possible.

IV. *Sacral Route.*—Every method by which the rectum is removed via the ral route is based upon the Kraske operation.

Kraske's Operation.—Place the patient on his right side with the thighs htly flexed.

Step 1.—Make an incision in the middle line from the middle of the sacrum the anal margin. This cut penetrates to the bone but does not cut through anal sphincter.

Step 2.—Detach the gluteus maximus on the left side from its sacral and cygeal origins.

Step 3.—Excise the coccyx.

Step 4.—Close to the sacrum, cut through the lower part of the left sacro-sciatic ligament.

Step 5.—With chisel or strong bone forceps excise the left half of that part of the sacrum lying below the level of the third posterior sacral foramen* (A, B, C, Fig. 639).

Step 6.—Expose the rectum by dividing the soft structures lying between it and the sacrum. *Do not open the gut.*

Step 7.—Separate the gut from its surroundings by blunt dissection. The rectal mesentery having been loosened (bluntly), pull the gut downwards to such an extent that after the diseased section has been freely removed the continuity of rectum may be restored by sutures on which no unnecessary tension

FIG. 639.
A, B, C. Kraske's line of section. H, K. Heineke and Kocher's line of section.

may be exerted. It is important not to have opened the gut, as in this step of the operation the peritoneum is frequently opened either by accident or design. If the gut is not opened and the tumor not invaded, the peritoneum must be closed by sutures or packing (preferably by sutures) after the rectum has been pulled downwards to the desired extent. If the peritoneal wound has become soiled, owing to escape of intestinal contents from an accidental tear in the gut, it must be cleansed and drained with iodoform gauze.

Step 8.—At a point about one and one-quarter inches above the disease (if it is malignant; closer, if non-malignant) divide the gut transversely and remove it to a point the same distance below the disease. Suture the upper segment of gut to the lower.

* Step 5 of Kraske's operation is frequently modified. It is found that much more of the sacrum may be removed, when necessary, than has been described above. The left half of the sacrum up to the second foramen has been excised, the spinal canal opened, and the lower fibres of the cauda equina removed without evil resulting.

› 9.—Cleanse the whole wound carefully. Diminish the size of the by a few stitches so applied as to avoid interfering with the freest pos-ainage. Pack the rest of the wound loosely with iodoform gauze. The closes by granulation. A fæcal fistula frequently results, as the intes-ıtures, especially the posterior ones, commonly give way.

.ske ("German Surg. Congress," 1906) thinks that laparotomy ought to be practised as an immediate preliminary to the sacral operation in f extensive disease in order to permit removal of lymphatic nodes. He the gut with the cautery between two ligatures and thus renders the egment mobile and easy of excision through the sacral route.

n's Modification of Kraske's Operation.—Instead of Kraske's median in-make a cut along the left side of the sacrum and coccyx and continue

FIG. 640.—Rehn's operation.

ırds the anus (A B, Fig. 640). If sufficient space is obtained by this ı, proceed with the other steps of the operation. If more room is re-, make a transverse incision (B C, Fig. 640) over the sacrum between rd and fourth sacral foramina. Separate the sacrum from the soft parts ıt of it and divide the bone along the line of the transverse incision. the newly formed flap, consisting of sacrum, coccyx, and soft struc-overing them, to the right.

: rest of the operation is practically identical with Kraske's, except ter the rectum is loosened from its connections and pulled down so far ıe suture of the divided ends (without tension) will be possible after the is removed, the whole wound is loosely packed with iodoform gauze : rectum left unopened and not relieved of the tumor. During the after-ent the patient must lie on his side. Keep the bowels locked up for ys with opium. On the fifth day move the bowels with castor oil and

enemata. After the lapse of about ten days from the primary operation, exci the tumor and suture the ends of the gut together. In doing so, first stit the mucosa with catgut and then unite the other coats with silk. It strengthe the line of sutures if the silk stitches include in their bite some of the neig boring soft parts.

It is claimed that, among other advantages, the operation in two stag lessens the immediate mortality of a very serious procedure—(*a*) because t shock is lessened, (*b*) because the huge wound cavity is well covered l granulations before there is much chance of its becoming soiled by intestin contents.

FIG. 641.—Schlange's operation.

A distinct disadvantage of Kraske's operation is that the levator and t sphincter ani muscles lose the support which they normally obtain from t sacrum and coccyx. This is important for the future comfort of the patie In order to save the sacrum and coccyx Heineke and Kocher (Fig. 639) ha divided the coccyx and lower end of the sacrum longitudinally in the mid line and retracted the fragments to either side, replacing them when the ope tion was completed. Schlange has attained the same object by a method wh affords much room and has given excellent results in his hands.

Schlange's Operation.—Step 1.—Make a transverse incision down to bone across the lower part of the sacrum.

Step 2.—From the above incision make two others (one on each side of coccyx) which diverge from each other slightly and end near the level of anus. Near the anus these two cuts merely penetrate the skin, but where t skirt the coccyx and lower end of the sacrum they divide the muscles and l ments inserted into these bones.

Step 3.—With a Gigli wire saw divide the sacrum transversely along line of the original skin-incision (Step 1). Reflect downwards the flap of b

d superjacent soft parts formed by the preceding steps (Fig. 641). The tum is isolated, tumor excised, and intestinal wound closed as in Kraske's eration. After attending to hemostasis the wound is loosely packed with loform gauze and the sacro-coccygeal bone-flap is partially replaced. The tient is kept on his side for a few weeks to avoid injury to the flap; the wound als by granulation and the flap gradually assumes its normal position. hlange was able to exhibit to the Berlin Medical Society a patient on whom had performed the above operation six weeks previously with a result per- t as regards both comfort and function.

Kümmel no longer (1906) excises much bone, nor does he use large bone- os. He excises no more than the coccyx. Rotter does the same, but leaves point of the coccyx with its muscular attachments. After dissecting free diseased segment of gut Rotter, if possible, resects this segment and re- ablishes the intestinal continuity. If resection is impossible he amputates diseased and distal portions of the gut, and pulling the upper segment of through a tunnel bored through the glutei muscles, establishes a gluteal is away from the large coccygeal wound. This little modification (estab- ment of gluteal anus) has been very life-saving.

Rotter's death rate has fallen from 32 per cent. before 1903 to 4¾ per t. since that date. His late results have been very encouraging. (See entralblatt für Chir.," July 14, 1906, or "La Presse Medicale," July 21, 06.)

W. J. Mayo's Modification of Kraske's Operation.—Place the patient in the endelenburg position, *but* on his face instead of on his back. The pelvis ist be supported at the end of the table and the hips more or less flexed. ie posture might be called the reversed lithotomy position.

Step 1.—Make a median incision from near the anus up to a point between e middle and base of the sacrum. Reflect the soft parts from the coccyx d the lower half of the sacrum. Divide the soft parts attached to the sides sacrum and coccyx all the way around these bones from one sacro-sciatic tch to the other.

Step 2.—With a chisel divide the sacrum transversely at the second foramen; , at the level of the sacro-sciatic notch. Excise the lower part of the sacrum d the coccyx. The mid-sacral artery will require ligation.

Step 3.—Divide the levatores ani in the middle line. With a pledget of uze wipe downwards the external and at least part of the internal sphincter the anus, separating these structures from the mucosa of the gut. (It is sumed that the mucosa here is not involved in the disease.)

Step 4.—Mobilize the rectum above the disease. Open the peritoneum d pack it with gauze. Pull the sigmoid (pelvic colon) downwards. Ligate d divide the inferior mesenteric artery. Open the two folds of meso-rectum d, wipe downwards all the fat and lymph tissue behind the rectum in the vity of the sacrum. All the diseased gut now lies loose except at its upper d lower ends.

Step 5.—Pull the rectum upwards so that the anus is pulled inwards (or wards). This is possible because the sphincters have already been separated m the anal mucosa. Clamp and divide the gut at the muco-cutaneous

junction. The loosened sphincters lie below the clamp. Clamp and divide the gut well above the disease. Remove the diseased segment.

Step 6.—Bring the rectal stump downwards; pull it through the anus until it protrudes one inch. Fix it in position with safety pins. If there is tension on the gut, incise the peritoneum more freely at the sides as this is the supporting force.

Step 7.—For a distance of three inches upwards from the anus suture the levatores ani muscles together and to the posterior surface of the gut. (If the internal sphincter has been divided and preserved, suture it along with the levatores.

Remove the peritoneal packs. Attach the peritoneum to the gut with interrupted sutures. Provide ample drainage by means of split rubber tubes containing strips of gauze. Partly close the external wound.

After forty-eight hours remove part of the drains (all of them if the wound seems clean). Fill the wound with Van Arsdale's fluid (5 per cent. balsam of Peru in castor oil). The Carrel Dakin treatment of the wound is good. Do not repack except to keep the external wound open.

Mummery's Method ("Brit. Med. Journ.," June 1, 1907).—Lithotomy position with pelvis raised on small hard cushion. (Combined lithotomy and Trendelenburg postures).

Step 1.—Dissect a cuff of mucosa from the anal canal for about 2 inches, as in the Whitehead operation for piles. With sutures or clamp completely close this tube of mucosa so that nothing can escape from the rectum. With cautery or pure carbolic sterilize the stump. Change gloves and discard all instruments used. Once more cleanse the parts.

Step 2.—Make a median incision through the sphincters backwards to and a little beyond the base of the coccyx. Remove the coccyx. Open the posterior rectal space and separate from the sacrum by gauze dissection all the glands, fat, etc., there present and push these structures forward in one piece along with the rectum.

Step 3.—Pull down the levator ani on each side with the finger. Divide the muscle close to the rectum. Separate the rectum from the prostate and urethra (or from the vagina). This requires much care.

Step 4.—Open the peritoneal cul-de-sac and divide the attachments of the peritoneum to the rectum first on one side and then on the other, keeping close to the rectum to avoid the ureters. This leaves the rectum free except for the meso-rectum.

Step 5.—Divide the meso-rectum as near the sacrum as possible after applying clamps or better suture ligatures. The rectum now comes down freely and the sigmoid presents. The lowest portion of the sigmoid is often provided with such a short meson that it cannot be brought to the anus without tension. Divide the meso-sigmoid, after applying clamps or ligatures until a portion of the gut is reached with mesentery long enough to permit easy union of gut to skin (see Fig. 642).

The tumor and all the rectum are now outside the wound. Do not yet divide the gut.

Step 6.—Attend to hemostasis in a painstaking manner. Suture the peri-

to the sides and front of the sigmoid. Close the wound after providing
garette" drainage. Be specially careful to suture the sphincters
ly.

7.—Divide the gut about ¾ to 1 inch distal to the sphincter. Fix
s of the divided gut by a few stitches *not* to the margin of the skin-
ut to the skin itself about 1 inch away from the wound. This greatly
the wound against fouling. Later the excess of mucosa can be cut
Introduce a short rubber tube into the bowel to permit passage of gas.
ressings.

FIG. 642.—(*Mummery, "Brit. Med. Jour."*)

st's Modification of Kraske's Operation.—Proust's account of this opera-
a Presse Med.," December 28, 1907) is so clear and so well illustrated
would be unjust to that surgeon and to the profession not to give a
scription of it here. For two weeks before operation give repeated
es and enemata. Give a final purgative forty-eight hours before opera-
ive opium sufficient to thoroughly constipate twenty-four hours prior
tion.

the patient on his left side, thighs slightly flexed and buttocks slightly
edge of the table. The ventral position may be used.
porarily close the anus with a purse-string suture.

1.—Same as in Mayo's method.

2.—Divide the sacrum transversely, four fingers' breadth above the
the coccyx, *i.e.*, on a line just below the third foramen. Remove the
rt of the sacrum and the coccyx. Ligate the mid-sacral artery which
he anterior surface of the bone. Apply moist, hot pads to the cut sur-
one to stop bleeding.

3.—The retro-rectal cavity with walls smooth as a serous bursa, is
n. Carefully tear a hole in the anterior wall of this cavity, *i.e.*, in the
otic sheath, and expose the posterior surface of the rectum, high up
n lie the superior hemorrhoidal vessels. Ligate these (Fig. 643). En-

FIG. 643.—Ligation of superior and middle hemorrhoidal vessels. (*Proust.*)

FIG. 644.—Ligation of branches of inferior mesenteric vessels. (*Proust.*)

large the opening in the sheath downwards to expose the middle hemorrhoidal vessels. Ligate these (Fig. 643).

Step 4.—Bit by bit separate the rectum from its sheath and push it to the left until the peritoneum appears at the upper part of the field. Open the peritoneum by a vertical cut in the middle line. Introduce the finger and hook it round the gut so that the point of the finger raises the peritoneum on the opposite side of the gut. Open the peritoneum here also. Pass a loop of gauze round the gut like a scarf for purposes of traction. Pack the peritoneum with gauze.

Step 5.—Pull the rectum, and with it the sigmoid, downwards. Successively ligate and divide the terminal branches of the inferior mesenteric vessels in the meso-sigmoid (Fig. 644). This dissection makes the descent of the sigmoid easy. Continue the dissection until the neoplasm and an ample suffi-

FIG. 645.—Closure of peritoneum and fixation of gut. (*Proust.*)

ciency of healthy gut is delivered and until healthy gut above the neoplasm can be brought easily and without tension to lie against healthy gut below the neoplasm. With the gut bring away all the suspected lymphatic tissue of the meson.

Step 6.—Partially close with transverse sutures the vertical wound in the peritoneum. Make each suture pass through the meso-sigmoid above the part which has been ligated and divided but do *not* include any vessels within the sutures. Tie the sutures. This partly closes the peritoneum and it fixes the gut so that it cannot retract upwards (Fig. 645).

Step 7.—Apply rubber-covered intestinal clamps to the gut above and below the lines chosen for division of the intestine. Lay the clamps alongside each other and unite the anterior surfaces of the two loops of gut by a row of continuous Lembert sutures on the tumor side of the clamps. Apply crushing clamps to the two loops of gut between the line of Lembert suture and the neoplasm. Divide the gut and remove the neoplasm. The crushing clamps prevent escape of contents from the gut being removed. Complete the end-to-end anastomosis of the gut (circular enterorrhaphy) (Fig. 646). The anterior and part of the lateral surfaces of the gut are usually covered by peritoneum if the tumor is fairly highly placed and hence good serous apposition

FIG. 646.—Anastomosis of gut. (*Proust.*)

can be attained. The posterior surface is devoid of serosa and hence union is less accurate. Proust therefore recommends that *no* attempt be made to cover this portion of the intestinal wound by gliding flaps of parietal peritoneum over it, but that the parietal peritoneum should be stitched to the gut in such fashion as to close the peritoneal cavity and leave the doubtful portion of the intestinal wound entirely extraperitoneal. If the tumor is found at too low a level to permit of safe end-to-end anastomosis the operation may be finished by Mayo's method.

Step 8.—Bring the edges of the skin wound together with stitches deep enough to catch up the subjacent tissues. Drain all dead spaces with loose gauze packing. Remove the purse-string suture which closed the anus temporarily. Apply dressings. Keep the patient constipated during one week.

Inguinal Colotomy as a Preliminary to Excision of the Rectum.—Should inguicolotomy be performed as a preliminary to excision of the rectum? Quénu ms to consider that such is always advisable; other surgeons seem to consider it it is always needless. Probably the truth lies between these extremes. Mummery considers colotomy unnecessary if it is possible to thoroughly pty the bowel of all retained fæces before operation so that one can be rally certain no fæcal material will find its way into the lower bowel for ne days after the operation and the bowels can be prevented from acting six or seven days. When the above cannot be accomplished preliminary otomy is advisable.

The disadvantages of a preliminary colotomy are mainly the following:

(*a*) The annoyance of an operation performed some days before the main ervention.

(*b*) The risk and annoyance of an operation performed to close the inguinal s some weeks after the main intervention.

(*c*) Adhesion of the sigmoid flexure to the abdominal wall at the site of artificial anus, interfering with the pulling down of the rectum necessary excise the tumor and approximate the divided ends of the gut.

This is *the real* objection to the operation, but it may be overcome either exercising care in choosing the part of the colon to be united to the abdomiwall or by making the artificial anus on the *right* side of the abdomen.

The main advantages of preliminary colotomy are as follows:

(*a*) Through the abdominal cavity one can explore the upper limits of an tensive cancer and observe the presence of serious lymphatic extension.

(*b*) One prevents the passage of fæces into the diseased rectum and can roughly irrigate it with solutions introduced either through the anus or rough the colotomy wound. During the after-treatment one is not dependt upon opium as a means of keeping the wound free from fæcal contamina-n. With the aid of a preliminary colotomy it is easy at least to approximate anliness in an excision of the rectum.

What are the indications for radical operation in rectal cancer?

Whenever cancer of the rectum is diagnosed, it should be removed at once. o much should be removed rather than too little. This should be the inriable rule except when the patient's local or general condition is such that e operation affords no hope of recovery, in which case palliative treatment, ., by colotomy, must be initiated.

From careful examination of a rectum excised for cancer Sampson Hardley mes to certain conclusions which may be epitomized as follows ("Brit. Med. urn.," April 16, 1910):

(*a*) That permeation of the growth may extend very widely in the mucous xus upwards and downwards, reaching in a comparatively early stage of e disease a point at least 5 inches from the edge of the primary disease. The ected section of the bowel may appear quite healthy to ordinary macro- and roscopic examination (mucicarmine is a specific stain for cancer cells underng mucoid degeneration) because the permeating cells have undergone romatous degeneration.

(*b*) Permeation of the mucous lymphatic plexus as a factor in dissemination

is probably limited in effectiveness by the habitual degeneration of the cancer cells in this situation.

(*c*) Cancerous infiltration in the muscular and peritoneal coats does not extend far from the primary growth.

(*d*) Effective dissemination probably occurs as a rule through the meso-rectum or peri-rectal tissue opposite the primary growth and hence this tissue must be removed.

(*e*) Because of the permeation referred to in (*a*) a great length of bowel should be removed including the sphincters.

A few years ago cancer of the rectum was considered beyond remedy by operation if the upper limits of the tumor could not be reached by the finger passed through the anus. Mere extent of tumor along the gut no longer contraindicates operation. Extension of the tumor through the intestinal walls and involvement of neighboring tissues is a matter of great import. As a general rule, it may be said that when the tumor has become absolutely immobile, the disease is so widespread that operation is worse than useless; that when the immobility is only partial it may possibly be due to simple inflammatory adhesions, and operations may be justifiable, though exceedingly dangerous. Esmarch does not consider involvement of the base of the bladder in the cancerous process a contraindication to operation—he boldly excises the diseased bladder-wall and sutures the defect. Extensive involvement of the pelvic lymphatic glands is a contraindication to operation which can rarely be utilized unless the abdomen is explored. If one practises preliminary colotomy, one has the opportunity to examine the pelvis before fixing the colon to the belly-wall.

Choice of Operation.—In most cases where the tumor is well within the reach and its uppermost extension can be easily palpated by the finger introduced through the anus, the operation through the anus or perineum may be chosen. In such localized and easily surmounted tumors the results are excellent.

Kelsey writes: "The advantages of the sacral incision may be briefly enumerated as follows:

"1. To dissect methodically cancers situated high up, and preserve the sphincters.

"2. To completely remove cancers distinctly circumscribed, but which would be inoperable by the older methods, their upper limit being beyond the reach of the knife.

"3. To preserve, in whole or in part, the external sphincter, even when the rectum is involved low down.

"4. To avoid the formation of a cloaca, even when the rectovaginal septum is invaded by the disease.

"5. To attack recurrent growths while yet limited, and give to the sufferers one more chance of health.

"6. Finally, to render more easy and precise the extirpation of non-malignant strictures."

Combined Abdominal and Perineal Rectectomy.—*Quénu's Method.*—*Step* 1.—Place the patient in Trendelenburg's position. Open the abdomen in the middle line below the umbilicus.

2.—Ligature of both internal iliac arteries. (This is for the control of lle and inferior hemorrhoidals.) Note the inferior border of the prom- of the sacrum; on each side of this can be felt the pulsation of the iliac arteries or of the common iliac if the division has not yet taken At this level, 1¼ inches (3 cm.) from the middle line and a trifle to the le of the pulsating artery, place the middle of a 2-inch incision through toneum alone. By blunt dissection retract the outer lip of the peri- ound and with it the ureter. Expose the common and the external eries. A little downwards and inwards expose the internal iliac and at a point a little more than ½ inch below the bifurcation (Fig. 647). eft side the ligation is not so easy as on the right, because the origin ieso-sigmoid hides the vessels. Two methods are possible: (*a*) Pref- hen the meso-sigmoid is short. Lay the sigmoid flexure against the iliac

FIG. 647.—Ligation internal iliac artery. (*Monod and Vanverts*)

ake an incision, symmetrical to that on the right side, so as to get the meson and expose the parietal peritoneum. Incise the exposed ım, retract the outer lip of the peritoneal wound, and proceed to the as on the right side. (*b*) If the meso-sigmoid is very long, pull the upwards, incise the parietal peritoneum immediately below the origin ieson, and thus reach the vessels directly. When it is evident that the of the left iliac will be difficult, it is simpler to put this step off until : sigmoid has been divided and the field of operation has been made access. While the iliac vessels are exposed, examine this region for lymphatic glands. Close the wounds made in the peritoneum over the

3.—At a point free from blood-vessels tear a hole in the meso-sigmoid ; a large strip of gauze through it (Fig. 648). Protect the abdominal ith gauze pads. With the fingers empty the contents from that portion igmoid opposite the tear in the meson. Doubly ligate the gut and : between the ligatures, preferably with the thermocautery. Cover ed ends of gut with gauze and rubber caps held in place by a thread or

a rubber band. This to prevent soiling. Working downwards from the tea
the meso-sigmoid, divide that structure between forceps or ligatures and p
aside temporarily the lower segment of gut. Sudeck's illustration (Fig. 6

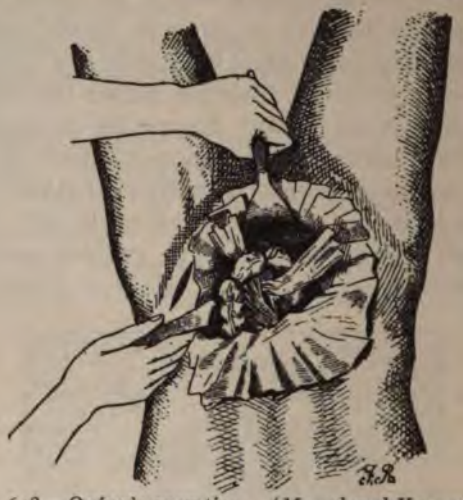


FIG. 648.—Quénu's operation. (*Monod and Vanverts.*)

FIG. 649.—Inferior mesenteric artery. (*Sudeck.*)

("Muench. med. Woch.," July 2, 1907) gives a very clear idea of the inferi
mesenteric artery. It is best, if possible, to ligate the artery after it gives
its last important anastomotic branch, *i.e.*, when the ligation is for hemosta
and not for mobilization.

Step 4.—Make an incision in the left iliac region through the parietes (F

and pull the divided end of the upper segment of gut through this.* Fix gut in position by a few sutures. A permanent artificial anus is thus pro-d. For Handley's modification see p. 518.

Step 5.—Pull the lower segment of gut (viz., that to be removed) forwards upwards against the pubis. Divide the meso-rectum and ligate the hem-oidal vessels. When the posterior connections of the rectum have been rated, proceed to incise the recto-vesical *cul-de-sac* if this is possible of access. the whole lower segment of gut, well covered with gauze pads, in the deepest of the pelvic fossa. Completely close the abdominal wound, after as s possible diminishing the peritoneal laceration by means of sutures applied ıe remnants of the meso-rectum.

Step 6.—Place the patient in the lithotomy position and complete the opera-by removing the loosened rectum and its protecting pads of gauze by the ıeal route, if necessary excising the coccyx and portions of the sacrum. ide for perineal drainage and close the perineal wound with sutures.

Step 7.—According to circumstances, either leave the portion of gut which been fixed in the left iliac region untouched for two or three days or open ımediately so as to empty the bowels. In the formation of the artificial the use of Paul's tube will aid in pre-ing soiling of the dressings.†

Modified Quénu Operation.—Step 1.—e the patient in the high Trendelenburg tion. Open the abdomen in the middle below the umbilicus. Examine as to the ibility of removing the disease. Protect he intestines with gauze pads, leaving the ıoid and rectum free.

Step 2.—Apply two clamps to the gut well ve the disease and divide the gut between n. Close each end of gut by a row of ıugh-and-through sutures. Invaginate stumps into the lumen of the gut by a ıe-string suture as in appendectomy. ve uncut the suture attached to the upper nent of gut; apply a hemostat to the end he suture; the suture will act as a guide he gut later.

FIG. 650.—Quénu's operation. (*Monod and Vanverts.*)

Step 3.—Pull the end of the lower segment of gut up into the wound. On ı side of the gut make a cut through the peritoneum of the meson parallel he gut and strip back the peritoneum. If the lower part of the sigmoid ns a part of the lower or rectal segment of gut, ligate its vessels which are ly seen. Continue the incisions in the meson downwards on each side of the um, stripping the peritoneum off the meso-rectum. Divide the peritoneum riorly so as to separate the rectum from the uterus, or from the bladder, tate, etc.

*This incision is best made in exactly the same way as in McBurney's muscle-splitting ation of appendectomy.

†The above description has been taken, practically completely, from Monod and Van-r "Traité de Technique Operatoiré."

Step 4.—Find and ligate the inferior mesenteric artery just to the left of t promontory of the sacrum. With gauze wipe downwards all the fat and ly phatic tissue posterior to the rectum; this is rendered possible by the incision reflection of the peritoneal surfaces of the meson. While wiping the fat do wards expose and ligate the middle sacral artery as high as possible. Cont

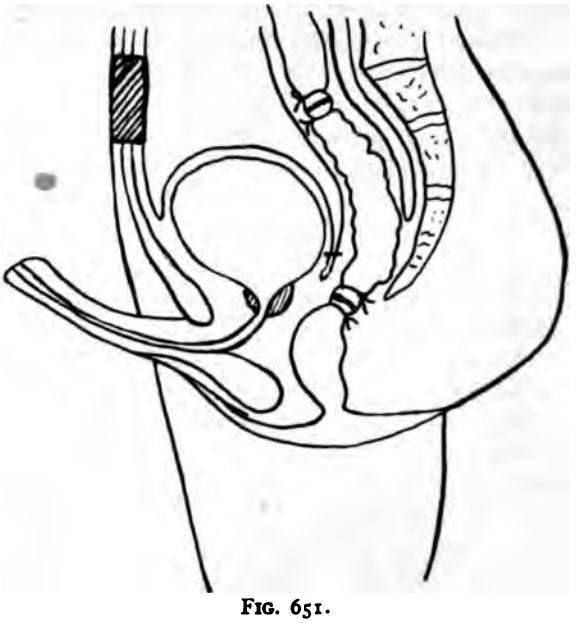


FIG. 651.

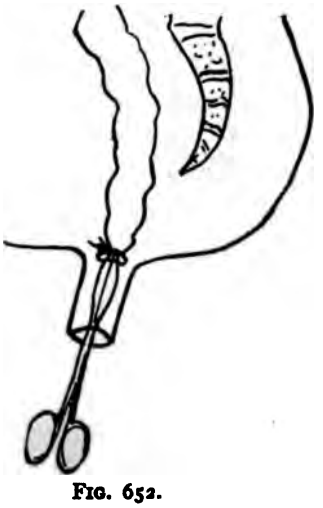


FIG. 652.

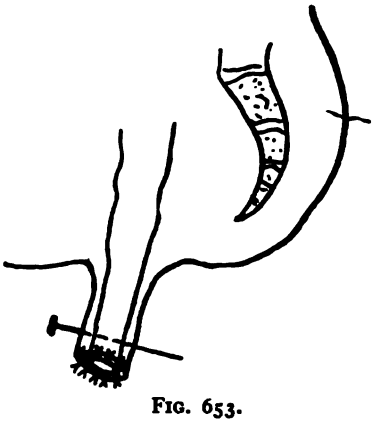


FIG. 653.

FIGS. 651, 652 AND 653.—(*Weir, "Jour. Am. Med. Assoc."*)

the gauze dissection, laying bare the internal iliac vessels and the ureters. and ligate the middle hemorrhoidal arteries which arise, one on each side, the anterior divisions of the internal iliac arteries and run inward to the m portion of the rectum.

Step 5.—If sufficient gut above the anus is healthy, complete the oper

by Weir's method. If restoration of the continuity of the intestinal canal is impossible or too dangerous, complete as in Quénu's operation.

R. F. Weir's Operation.—This operation is suitable in cases of cancer situated high up in the rectum.

Step 1.—Open the abdomen in the middle line or through the left rectus muscle.

Step 2.—Free the rectum from its connections to a point near the tip of the coccyx posteriorly and to the edge of the prostate anteriorly.

Step 3.—Divide the gut between two ligatures above the tumor (Fig. 651).

Step 4.—By means of forceps passed up through the anus seize the upper end to the lower segment of gut and pull it out through the anus, thus inverting the gut. Cut away the tumor.

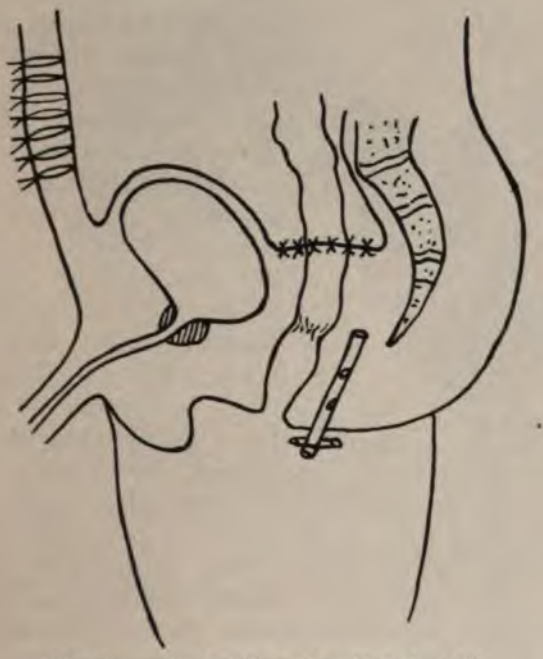


FIG. 654.—(*Weir, "Jour. Am. Med. Assoc."*)

Step 5.—Pull the distal end of the proximal segment through the inverted lower segment. The serous surfaces of the two segments lie in apposition. Unite the two segments by means of Maunsell's method of suturing (Figs. 652 and 653).

Step 6.—Reduce the prolapsed gut. Suture the pelvic peritoneum divided when freeing the rectum from its connections (Fig. 654). This suture shuts off the general peritoneal cavity from the deep portion of the pelvis. Drain the lower portion of the pelvis through an incision made behind the anus (Fig. 654).

Maunsell and Trendelenburg have performed a very similar operation, but drain the deep pelvis with gauze brought out through the abdominal wound.

Miles Operation (Brit. J. Surg., Oct., 1914).—*Step* 1.—Place the patient in the high Trendelenburg position. Make an incision just to the left of the linea alba from the symphysis pubis to or beyond the umbilicus. Examine the liver for metastases. Examine the pelvic mesocolon for nodules or plaques of growth, if such are present or if the bladder or vagina are involved in the disease the case is inoperable. It is important to have the pelvis cleared of all the small intestines and if it is impossible to keep them out of the way in the upper abdomen Miles does not hesitate to pull them out of the wound and let them hang down outside the abdomen protected by an abdominal swab wrung out of warm salt solution.

Step 2.—Draw the pelvic colon through the wound, if necessary, mobilizing it by incising the *outer* side of its mesocolon. This mobilization exposes the colonic vessels and permits of the proximal segment of colon being subsequently used for colostomy without undue tension. Choose a point on the bowel between the anastomotic loops of the first and second sigmoidal branches of the inferior mesenteric artery and apply to the bowel a powerful crushing forceps for about two minutes. Miles clamp has a blade 1 inch wide. Remove the clamp and pass a stout thread through the meson at each extremity of the crushed area and tie firmly (Fig. 655). Divide the bowel between the ligatures and also divide a portion of the mesocolon which has also been crushed. Invaginate the ligated ends of the bowel by means of purse-string sutures.

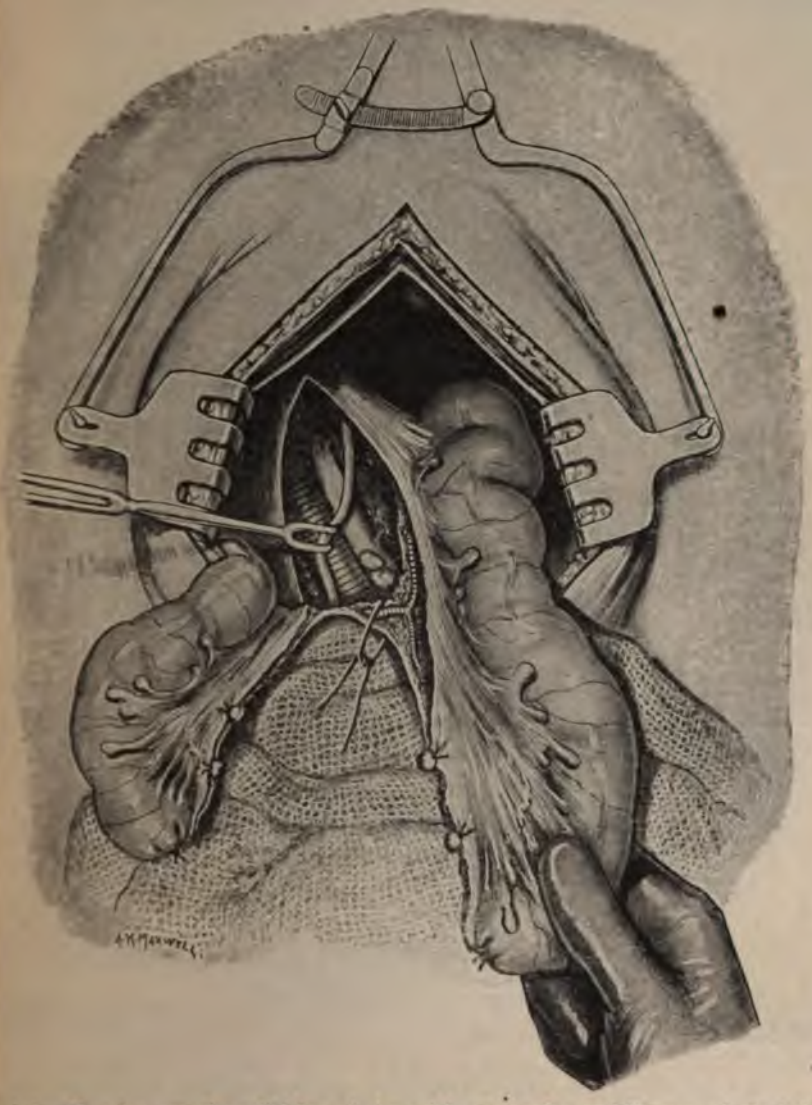
FIG. 655.—Showing the crushed area of the bowel after removal of the clamp.

A ligature is passed through the mesocolon close to the bowel on either side of the crushed area, and tied firmly. The interrupted line indicates the incision to be made through the crushed bowel and adjacent portion of the mesocolon. (Illustration taken from Mr. Ernest Miles' paper in the *British Journal of Surgery*, October, 1914.)

Step 3.—Make an incision through the peritoneum on the outer aspect of the pelvic mesocolon along its parietal border at the level of the left sacro-iliac synchondrosis. Note and avoid the left ureter as it crosses the common iliac artery (Fig. 656). This is important because the ureter is parallel and close to the inferior mesenteric vessels and might easily be ligated with them. Ligate the inferior mesenteric artery immediately below the origin of the first sigmoid branch. If the first and second sigmoid arteries arise by a common trunk do not ligate the trunk but tie the first sigmoid below the trunk and the second when the mesentery is divided. Divide the remainder of the pelvic mesocolon, the inferior mesenteric vessels as they lie in its parietal border being also divided below the point of ligature. Drop the proximal end of the colon temporarily into the abdominal cavity.

Step 4.—Beginning at the point where the pelvic mesocolon has been cut across, make an incision on either side of the attachment of the lower portion of the pelvic mesocolon at a distance of about 1 inch from it. Carry these incisions downwards parallel to the mesocolon to the level of the peritoneal

lexion in the pelvis. These incisions are in the posterior parietal peritoneum each side of the meson and 1 inch from it. This gives access to lymphatics ich extend under the peritoneum to each side of the meson. Pull the distal



. 656.—Showing complete division of the pelvic mesocolon and ligature of the inferior mesenteric artery at the seat of election.

The portion of the bowel on the left-hand side is that from which the colostomy is eventually made. incision in the peritoneum, carried forward on the left side, exposes the left ureter as it crosses the common iliac vessels. The ureter is drawn aside while the ligature is placed around the inferior mesen- vessels. (Illustration taken from Mr. Ernest Miles' paper in the *British Journal of Surgery*, October, .)

ment of colon forwards and open the connective-tissue space in front of the cavity of the sacrum. By finger and gauze dissection, from above down- ds, detach the rectum (ensheathed in the fascia propria recti) along with its

meson, blood-vessels and lymphatic glands from the ligamentous structures in front of the sacrum (Fig. 657).

Carry this separation down to the level of the sacro-coccygeal articulation which may be recognized by the firm attachment of the fascia propria recti to the end of the sacrum. Do *not* injure the median sacral veins.

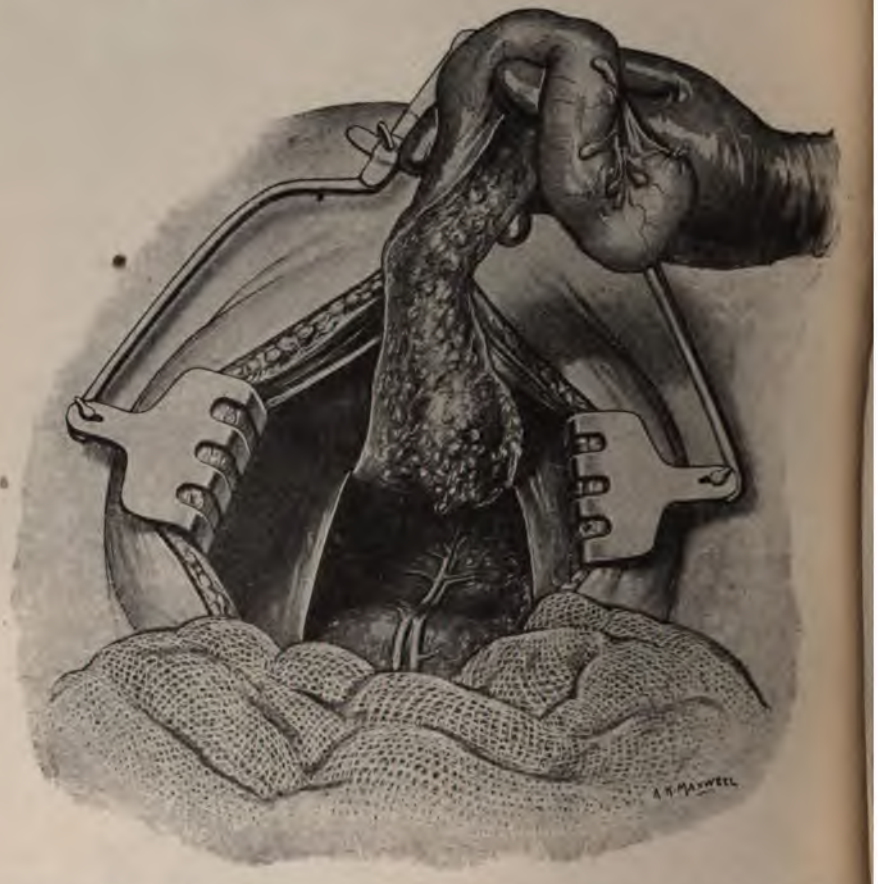


FIG. 657.—Showing the rectum and the retrorectal tissues separate from the hollow of the sacrum as far as the sacrococcygeal articulation.

After ligature of the inferior mesenteric vessels, the remains of the pelvic mesocolon are divided below the ligature, and the incisions in the pelvic peritoneum are carried forwards on either side along the lateral wall of the pelvis. The cellular space in front of the sacrum is opened up as far as the coccyx. (Illustration taken from Mr. Ernest Miles' paper in the *British Journal of Surgery*, October, 1914.)

Step 5.—Bring the two peritoneal incisions forward around the rectum to meet behind the base of the bladder in the male or the upper portion of the vagina in the female. Look out for the ureters which are adherent to the parietal peritoneum as they skirt the lateral wall of the pelvis on their way to the bladder.

Bluntly separate the anterior wall of the rectum from the bladder and seminal vesicles as far as the upper border of the prostate, in the male looking out for and avoiding the vasa deferentia, and from the vagina in the female.

ep 6.—The lateral ligaments of the rectum are two strong bands of con-
ve tissue, each about 1½ or 2 inches deep, extending from the sides of the
m forwards and outwards towards the base of the bladder (Fig. 658).

658.—Showing the separation of the anterior connections of the rectum as far as the upper border of the prostate, and division of the lateral ligaments.

he lateral incisions in the peritoneum have been extended on either side so as to meet in front behind ase of the bladder. The lateral ligaments have been defined as far as the upper surface of the levator n either side. These ligaments are then completely divided with scissors, the ureter on the left side g been drawn aside. (Illustration taken from Mr. Ernest Miles' paper in the *British Journal o* ry, October, 1914.)

rate the rectum from its lateral attachments. On the left side never lose t of the ureter as it lies close to the rectum and is easily injured. On the the ureter is more remote and ought to be left undisturbed in its attach- to the parietal peritoneum.

Divide the lateral ligaments *completely*. Failure in completeness of section renders the perineal portion of the operation difficult. When divi the left lateral ligament do not forget the ureter. The middle hemorrho arteries lie in the lateral ligaments but are small and rarely require ligatio

Miles remarks that these are the only branches of the internal iliac arte divided during the abdominal part of the operation and hence there is no us preliminary ligation of the internal iliacs as is sometimes advised.

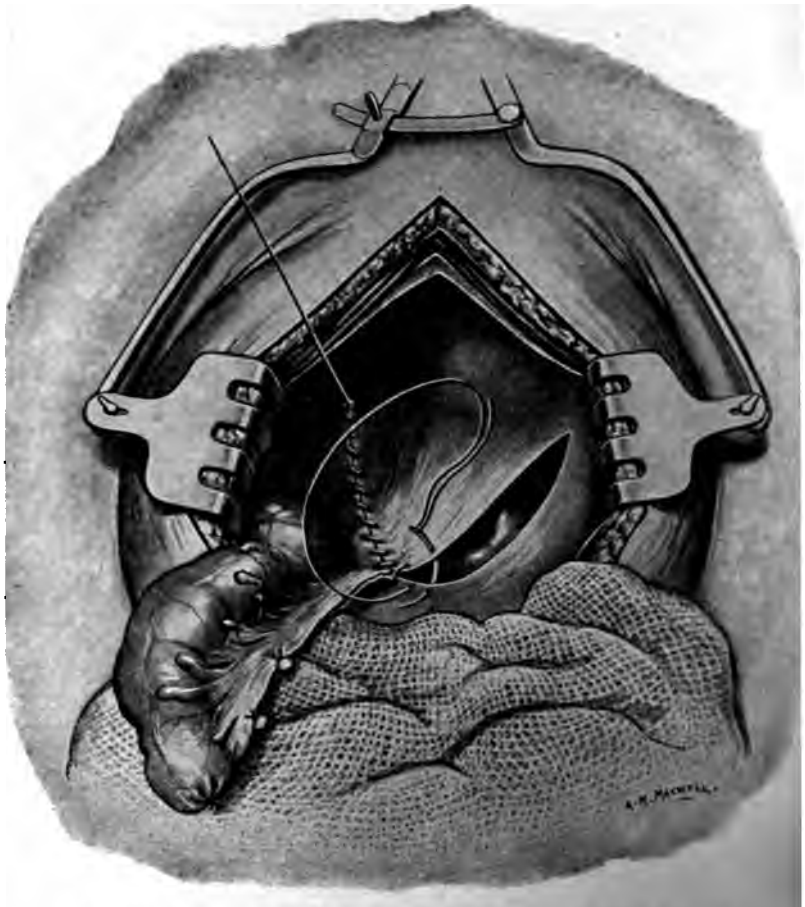


FIG. 659.—Showing method of restoring the pelvic floor of the male.

A flap of peritoneum has been dissected up from the bladder and drawn backwards until it meets cut edge of the pelvic mesocolon, to which it is sutured. On the right side the distal portion of the p colon can be seen lying in the pelvic cavity below the new pelvic floor. (Illustration taken from Ernest Miles' paper in the *British Journal of Surgery*, October, 1914.)

Step 7.—The rectum having been freed in all directions, anteriorly as as the upper border of the prostate or half way down the posterior vagina posteriorly as far as the sacro-coccygeal articulation, and laterally down levatores ani, push it down into the cavity of the pelvis. The perito each side of the pelvic mesocolon has been widely excised (this incisio

mentally important to prevent recurrence); therefore a large gap remains which must be closed. Dissect the peritoneum freely up from the lateral walls of the pelvis (avoiding injury to the ureters) until the posterior margins can be brought together in front of the promontory of the sacrum, without undue tension, and sutured to the stump of the pelvic mesocolon where the inferior mesenteric vessels have been tied. A large pear-shaped gap still remains. In the male dissect up a flap of peritoneum from the bladder, lay it across the gap and suture. In the female dissect up the innermost layers of the broad ligaments and use the flaps to fill the defect (Fig. 659). It is tempting to use the uterus to cover the gap but Miles found that menstrual troubles resulted. Omental grafts may be required to supplement the peritoneal flaps.

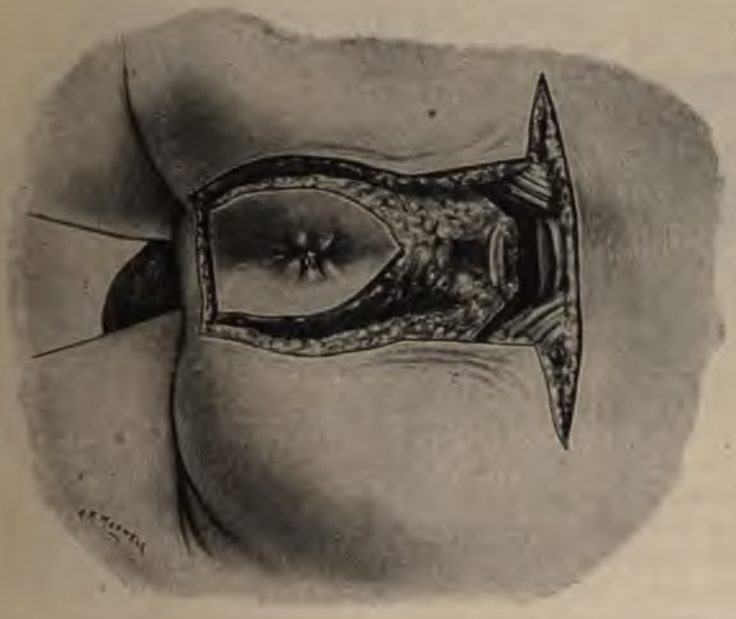


FIG. 660.—Showing the reflection of the skin flaps and opening of the sacrococcygeal joint. When the surface incisions around the anus are deepened, as much as possible of the ischiorectal fat is included. (Illustration taken from Mr. Ernest Miles' paper in the *British Journal of Surgery*, October, 1914.)

Step 8.—Pull the proximal segment of colon through a small incision about 1 inch internal to the left anterior superior iliac spine and establish an artificial anus (it is well not to open the new anus for some time).

Step 9.—Attend to the toilet of the peritoneum. Introduce two or three pints of warm saline solution into the abdomen. Close the wound. Apply dressings.

Step 10.—Place the patient in the right dorsal semiprone position. Close the anus by a purse-string suture. Make the incision shown in Fig. 660. Open the sacro-coccygeal articulation and remove the coccyx. Make a small

transverse incision into the dense connective tissue immediately below the sacrum, where the attachment of the fascia propria recti can readily be detached from the front of the lowermost piece of the sacrum. Thrust the index finger into this and so into the space containing the isolated bowel. Divide the coccygei muscles transversely on each side, extending the cuts outwards as far as the sacro-sciatic ligaments (Fig. 661). Pull the bowel out through this wound. If in the earlier stages of the operation the anterior connections of the rectum have been separated down to the prostate, the base of the bladder,

FIG. 661.—Showing the pelvic colon and the isolated upper part of the rectum withdrawn from the cavity of the pelvis.

If the isolation of the rectum has been efficiently carried out anteriorly, posteriorly, and laterally, the bowel can be readily withdrawn, in the manner shown, and the base of the bladder, the vesiculæ seminales, with the vasa deferentia and the prostate gland, are clearly exposed to view. The levatores ani are then divided close to their origin from the pelvic wall. (Illustration taken from Mr. Ernest Miles' paper in the *British Journal of Surgery*, October, 1914.)

the vesiculæ seminales, the vasa deferentia and the upper part of the prostate, come into view. In the female, the uterus and upper half of the vagina are exposed. Pull upon the bowel and thus put the levatores ani on the stretch. Divide them close to the lateral wall of the pelvis. If these muscles do not come into view on traction being made it is because the lateral ligaments of the rectum have not been sufficiently divided in step 6. Until these ligaments have been completely divided, delivery of the bowel is difficult and the levatores cannot be divided.

If the growth is situated on the anterior wall of the ampulla, Miles always removes the prostatic capsule with the rectum.

Dissect the anal canal from the perineum avoiding injuring the membraneous urethra.

Step 11.—Pack the huge cavity with strips of gauze to support the pelvic floor which is formed only of peritoneum, but place a sheet of protective or rubber dam between the gauze and the walls of the cavity to prevent adhesion. Adhesion of the gauze to the peritoneum has caused serious trouble. Close most of the wound with sutures. Apply dressings.

Tuttle's Operation.—("Amer. Journ. Surg.," June, 1910.) Prepare the patient during several days by diet, purges, irrigations, etc. Immediately before operation irrigate the rectum with a 3 per cent. solution of formalin, wiping this out and then injecting two or three ounces of pure peroxide of hydrogen up into the rectum and above the tumor if possible.

Step 1.—Put the patient in the Trendelenburg position. Freely open the abdomen by a longitudinal incision just outside the left rectus muscle. Examine for adhesions, metastasis, etc.

Step 2.—Treatment of meso-sigmoid. Select "a point on the sigmoid two inches further above the tumor than the latter is above the anus." Make a small incision in the peritoneal layer of the meso-sigmoid, one-half inch from the margin of the gut; introduce through the incision a thin spatula-like director and on this as a guide incise the peritoneum parallel with the gut down to the tumor. Turn the gut over and repeat the process on the other side of the meso-sigmoid. Strip the peritoneum back on both sides of the meson to its origin on the posterior abdominal wall. Division of the peritoneum as described permits the gut to be pulled further out of the wound and facilitates tying the blood-vessels and removing the glands.

Step 3.—The gut being pulled upwards through the wound, begin near the origin of the visible vessels to brush all fat and glands from them by gauze dissection, towards the intestine until the lower sigmoidal artery is found and traced to its origin in the superior hemorrhoidal. Doubly tie and divide the superior hemorrhoidal artery just above the origin of the lower sigmoidal, which point is usually just below the promontory of the sacrum and in the angle of the iliac vessels.

A glance at Fig. 662 shows that if the ligation is made as directed (XX′) the anastomosis between the colonic and hemorrhoidal vessels is ample to keep up the circulation in the latter. An extra amount of mobilization may be obtained by double ligation and division of another anastomotic trunk at YY′ without interference with the rectal nutrition.

Step 4.—Split the deep fascia behind the lower stump of the ligated vessels and peel the rectum, fat and glands out of the sacral cavity down to the tip of the coccyx posteriorly and to the upper surface of the levatores ani on the sides. Pack the cavity with hot moist gauze to control oozing.

Step 5.—Carry the peritoneal incision "across the gut one inch above the tumor and through the cul-de-sac between the gut and the bladder or the uterus as the case may be."

Separate the gut from the anterior organs by blunt dissection as far down as possible without too great traumatism, usually as far as the prostate at least.

Step 6.—Remove the gauze from the sacral cavity. Examine the sigmoid and on it choose the lowest portion (well above the tumor) where the nutrition is above reproach. Carry this part of the sigmoid down to the tip of the coccyx to measure whether it can be brought out of the anus without tension. If it cannot, study whether it is the blood-vessels or the peritoneal covering of the meso-sigmoid which holds it. If the peritoneum, then increase the incision made in Step 2; if the vessels, feel which one is at fault and divide it between two ligatures (Fig. 662, YY′) in such a manner as not to interfere with anastomosis.

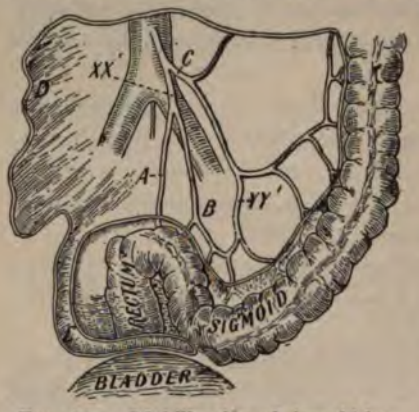


FIG. 662.—Mobilization of sigmoid by division of vessels.

Step 7.—*Method A*.—The tumor is of moderate size and is three inches or more from the anus. Tie a narrow tape with long ends around the gut just above the tumor. Have an assistant dilate the anus and pass through it a long dressing forceps to a point just below the tumor. Protect the abdomen with pads. Make the points of the forceps perforate the gut just below the tumor; seize the ends of the tape with the forceps and pull them into the gut and out through the anus. By pulling on the tapes and pushing the tumor downwards, the tumor is invaginated into the lower segment of gut and out through the anus dragging after it the lower segment of mobilized sigmoid to the desired extent. Replace all reflected flaps of peritoneum and repair all peritoneal wounds with sutures until the floor of the pelvis and the meso-sigmoid are entirely restored. Close the abdomen. Put the patient in the lithotomy position. Cut through the rectum or surrounding tube (intussuscipiens) all around, catch the edges with forceps. Through this circular wound note the intussuscepting sigmoid (intussusceptum) and find the lowest point in it where the circulation is good (prove that the circulation is good by puncturing with a needle) and yet which is high enough above the tumor. Suture this portion of sigmoid to the wall of the everted rectum. Cut away the gut below the line of suture and stitch the mucous membrane of the sigmoid to that of the rectum. Pass a large rubber tube into the rectum. With four sutures passed through the margin of the gut and the skin outside the anus prevent retraction inwards of the line of suture until union has taken place. Mayo uses safety pins instead of sutures. Drainage is secured by a tube or cigarette drain introduced into the hollow of the sacrum through a cut made alongside the coccyx.

Method B.—The tumor is high up and too large to be evaginated through the anus. Have the assistant make an incision alongside the coccyx and through this pull out the tapes and with them the sigmoid. Repair the peritoneum and close the abdomen. Excise the tumor through the parasacral incision, enlarging this if necessary. Unite the ends of the gut by circular

sutures or evaginate them through the anus and treat them after the manner described in Weir's operation, page 507.

Balfour's Operation.—("Annals of Surg.," Feb., 1910.) Suitable for tumors near the junction of the rectum and sigmoid.

Step 1.—Place the patient in the high Trendelenburg position. Excise the tumor in the usual manner, through an abdominal incision.

Step 2.—Provide a rubber tube about ¾ inch in diameter similar in stiffness to those used for colonic lavage. The tube should have a lateral eye near its end to permit the escape of gas should the end become obstructed. Pass the tube from the abdomen through the lower segment of gut so as to protrude through the anus. Pass the "eyed" end of the tube into the proximal segment

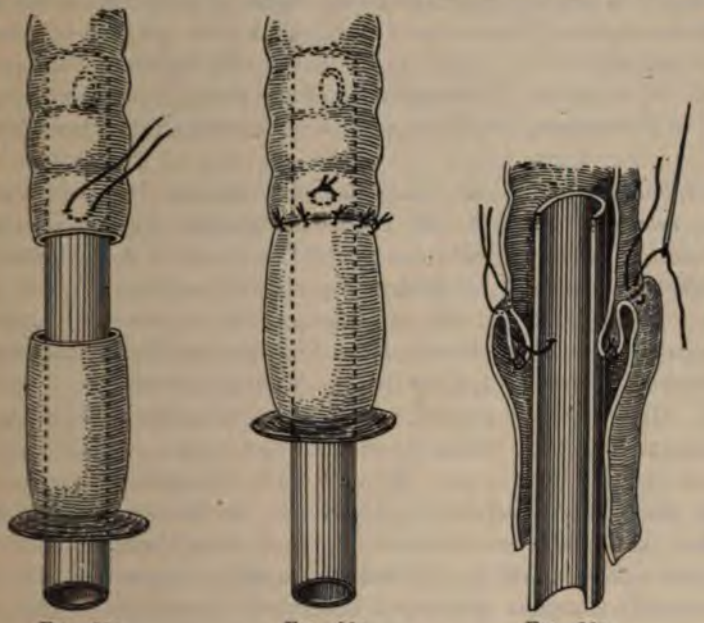


FIG. 663. FIG. 664. FIG. 665.

FIGS. 663, 664 AND 665.—Balfour's operation.

of sigmoid for about 3 inches having previously prevented accidental extrusion of fæcal matter by the application of a guarded clamp placed sufficiently high above the line of section. One-half inch above the cut end of the sigmoid fix the tube to the intestine by a transverse stitch of catgut (Fig. 663).

Step 3.—Have an assistant pull upon the tube projecting from the anus until the cut ends of the proximal and distal segments of intestine are in apposition. Unite the upper to the lower segment of intestine by carefully applied, interrupted, through-and-through sutures of chromicized catgut. Be careful to coapt the mucous membranes (Fig. 664).

Step 4.—Have the assistant once more pull upon the protruding tube so as to produce an invagination of the proximal for about ½ inch into the distal segment of gut. Assist this invagination by steadying the lower segment of the intestine with a few forceps. Insert sero-muscular sutures around the invagination to prevent the withdrawal of the intussusceptum (Fig. 665). (Occasion-

ally it has been impossible to insert the second row of sutures and yet good results have been obtained.)

Step 5.—Repair the peritoneal wound behind the anastomosis by sliding the peritoneum and suturing it. Pull the omentum down over the site of anastomosis and, if necessary, secure it there by a catgut suture.

Step 6.—Close the abdomen after providing for drainage.

The rubber rectal tube remains *in situ* until the catgut suture is absorbed (about six days). Do not remove the abdominal drain for one week because a temporary fæcal fistula sometimes occurs.

Rotter ("Handbuch der praktischen Chirurgie") writes: "The tendency of the French to make a permanent iliac anus in every case is not approved in Germany. Whenever practicable, we endeavor to preserve the sphincter ani, and consequently continence. This, as a rule, can be attained. The danger of infection is very slight, as the gut is only opened at the end of the operation. If union of the divided ends of the gut is impossible owing to the shortness of the upper segment, we prefer to make a sacral rather than an iliac anus."

German surgeons, as a rule, make use of an abdomino-dorsal instead of an abdomino-perineal operation. By the sacral (dorsal) route they expose and free the rectum as far as conditions permit, and then, if they meet with difficulties, open the abdomen, mobilize the gut to the necessary extent, close the abdominal wound, and pull the gut (rectum and, if necessary, sigmoid) out of the sacral wound, when the neoplasm is excised and the divided ends of gut united by circular enterorrhaphy or by the invagination method.

W. E. Miles has had a large experience in both the perineal and sacral operations and found the ultimate results to be atrocious; in fact there was recurrence in 55 out of 58 patients. He operates by the combined method (p. 508) removing nearly the whole of the pelvic colon, the whole of the corresponding meso-colon, the whole of the levatores ani, the whole of the rectum and anus and ischio-rectal tissues, making a permanent inguinal colostomy. His patients have practically complete sphincteric control of the abdominal anus which is neither unsightly, uncleanly nor a source of discomfort. He writes: "The operation is a severe one. I do not think that it should be performed on those over 60 years of age; of 10 such cases all died. With regard to the remainder, of whom there were 36, 8 died from the effects of the operation, 4 have had recurrence, 2 died of intercurrent disease, while 22 are to-day alive and well after periods varying from six months to six years" ("Brit. Med. Journ.," Jan. 25, 1913).

Handley ("Universal Med. Record," 1912, 385) has improved on the method of performing the combined operation as follows: When the gut has been divided above the disease (Step 4, Quénu's operation, page 463), completely close the end of the bowel which is to form the future artificial anus and bring it out through a stab incision just within the left anterior superior spine (possibly better control may be obtained by making the incision through the left rectus muscle). At the end of the operation make a small stab into the blind protruding end of the bowel, introduce a rubber catheter and tie it in with a purse-string suture. Use the catheter for the exhibition of salt solution by the drop method or when the solu-

ion is not being given permit flatus to escape by it. About the fifth day excise he protruding bowel and form the artificial anus. Handley advises the use of anti-streptococcic serum and of mixed staphylococcic vaccine as a preliminary to operation.

CHAPTER XXXVII

HÆMORRHOIDS AND FISTULÆ

External Hæmorrhoids.—External hæmorrhoids are practically never operated on except when inflamed. It is well to snip away with scissors any tags of skin around the anus at the same time as the pile is attacked; this to avoid subsequent trouble.

Hold the inflamed pile between the finger and thumb of the left hand. Transfix the base of the pile with a knife in the direction of the radiating anal folds. Cut outwards between the finger and thumb, thus splitting the pile. By squeezing or with a forceps or curette evacuate the contained blood-clot. Remove with scissors redundant tissues. Sutures are unnecessary. Apply a little simple ointment and a pad of cotton. The after-treatment consists in keeping the bowels open, occasional washing of the parts, reapplication of ointment and pad and the exercise of moderate patience for a few days.

Internal Hæmorrhoids.—*Preparatory Treatment.*—Evacuate the bowels thoroughly. Allingham advised giving two pills each containing blue mass gr. j. with gr. v. of pil. colocynth. et hyoscyami thirty-six hours before operation and using an enema of soap and water a few hours prior to operating. This method is as good as any.

Methods of Operating.—I. *Excision.*—(*a*) Place in lithotomy position. Dilate anus completely with thumbs or bivalve speculum. Catch each pile to be removed in a forceps. The removal of three pile masses is all that is usually necessary; if more are removed stricture may result. Cut away the lowermost pile with scissors. Pick up and ligate all bleeding vessels. Suture the wound. The operation is easy *on paper*, but it is not easy to pick up the vessels and to apply the suture neatly. Before it was customary to dilate the anus completely, excision was dangerous because of concealed hæmorrhage into the rectum. This danger no longer exists.

(*b*) Thelwell Thomas' method is a type of operation devised by many surgeons.

Lithotomy position: Completely dilate anus.* Catch the pile masses in forceps. Grasp the base of one pile in a forceps having a blade about 2½ inches long and not too thick. Be careful not to include any of the skin in the forceps. Cut away the pile about ⅜ inch distal to the forceps. Arm a stout catgut suture about ten inches long with a rounded needle at each end. Pass the suture through the upper end of the stump distal to the clamp and tie firmly. Do not cut the suture, but pass the needles one from one side, the other

*Many surgeons avoid dilating the anus claiming that recovery is more perfect than where it is dilated.

from the other side through the stump about ⅜ inch away from the first stitch and tie firmly over the stump. Repeat the stitch (Fig. 666) as often as necessary to completely suture the stump. Remove the clamp. There may be a little oozing from the mucous membrane where crushed by the clamp. Treat the other tumors in the same way. It is usually only necessary to remove three pile masses. If more tumors must be removed and stricture is feared, Thomas advises to apply the clamp to one or more of the tumors transversely to the axis of the gut and suture in the same direction, the resulting scar being transverse also.

After-treatment.—On completion of the operation introduce two suppositories, one containing 3 grs. of iodoform, the other ½ gr. of morphine. Apply a pad of gauze or cotton and some simple ointment to the anus.

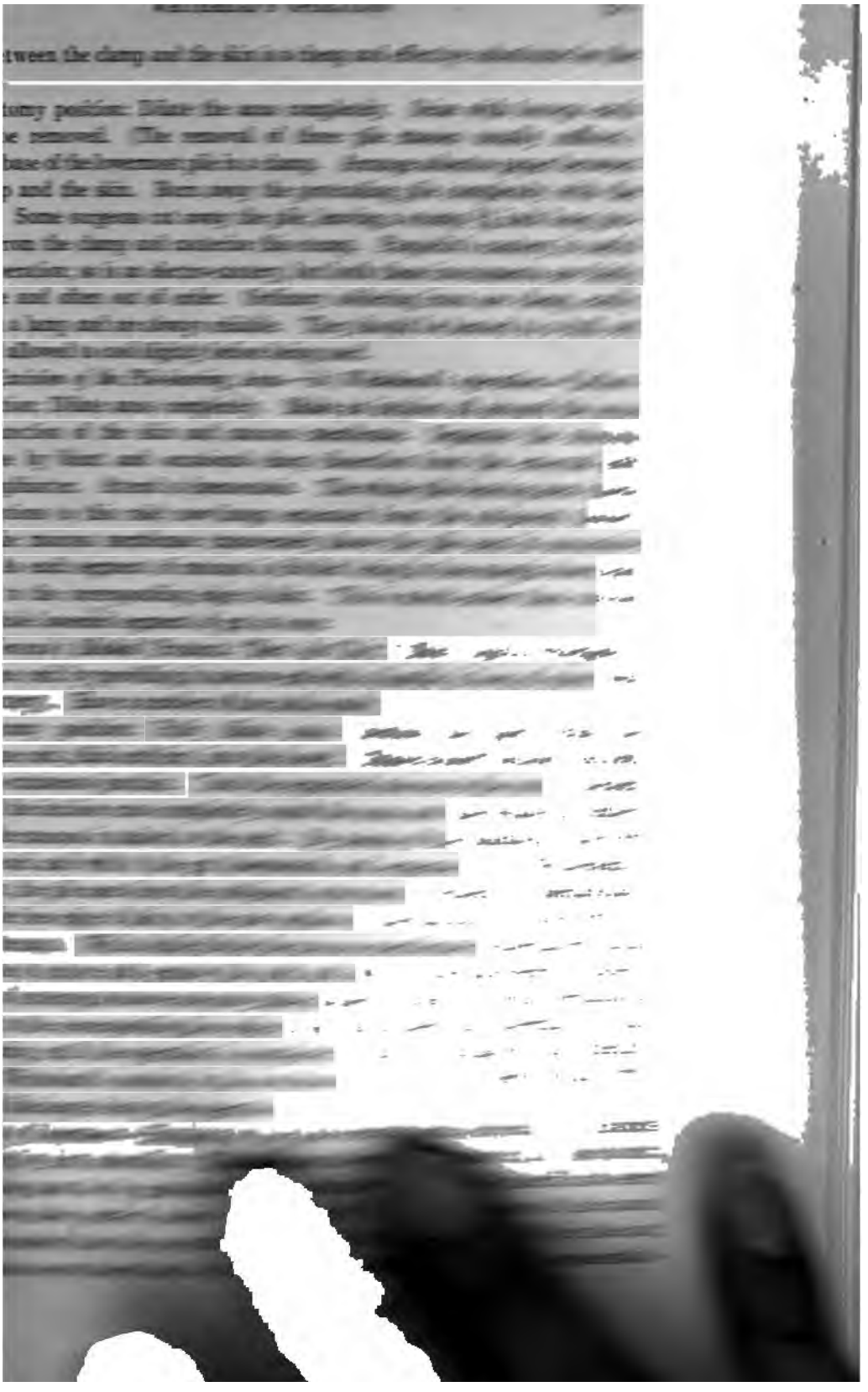
FIG. 666.—Excision of piles.

On the fifth day give a laxative. After the bowels move, introduce an iodoform suppository. The author finds that there is little use in keeping the bowels locked up; if they show a tendency to move it is satisfactory to give an enema of a few ounces of warmed oil. A favorite dressing with some surgeons is to introduce into the rectum a tube surrounded by gauze: the tube permits the exit of gas; the gauze is supposed to keep the wound clean and prevent bleeding. This dressing ought to be reserved for personal enemies and malefactors as it does no good and can cause much suffering. After excision the patient is generally well by about the seventh day.

II. *Ligation.*—(*a*) Lithotomy position: Dilate the anus completely. Catch the piles to be removed with forceps. Pull the lowermost pile downwards by the forceps attached to it. Note the white line at the junction of the skin and mucous membrane; beginning at this line immediately below the pile, with scissors separate the pile from the subjacent submucous and muscular tissues on which it rests. Continue the separation upwards until the pile remains hanging by a small pedicle of vessels and mucous membrane. This is possible and safe because all the vessels enter or leave the tumor above, immediately under the mucous membrane. Tie the pedicle tightly with a strong but not thick silk ligature. Cut away the tumor distal to the ligature. Before applying the ligature it may be convenient to crush a groove in the pedicle with a strong forceps. This permits the use of a lighter ligature. Treat the other piles in the same manner.

(*b*) Modified ligation: Separate the pile as for ligation. Divide the mucous membrane above the pedicle so that the pedicle comes to consist of vessels alone. Ligate the vessels with catgut. Suture the mucosa. This operation is practically an excision.

III. *Clamp and Cautery Operation.*—Many clamps have been devised. The simplest are Langenbeck's, Smith's or Gant's. Some have ivory on the under side to keep the heat from burning the skin. A piece of asbestos paper



lished. The same cause may lead to incontinence of gas and fæces. The other methods of operating all give good results. Each surgeon *knows* that the method he uses gives better results than any other. The author's preference is for the Thelwell Thomas operation.

Pruritus Ani.—In long-standing cases of pruritus where medical treatment has failed to give relief and where no evident removable cause for the itching can be found, a cure may be effected by one of two operations:

I. *Cauterization.*—Administer a general anesthetic. Thoroughly dilate the anus. Remove any tags of skin or small polypi which may present. Apply lightly the flat side of a Paquelin cautery, at a white heat, to every part of the affected anal skin. Only the superficial epithelium ought to be destroyed and on recovery there should be no scar formation.

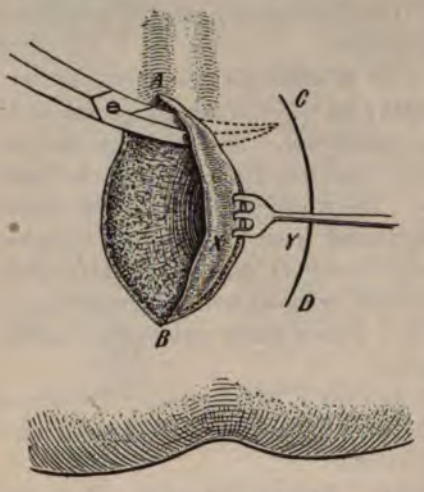


FIG. 667.—Operation for pruritus ani.

II. *Ball's Operation.*—Division of the terminal branches of the nerves supplying the affected skin.

Step 1.—The patient being in the lithotomy position, make the incision A B (Fig. 667) on one side of the anus and reflect the flap X, consisting of skin and subcutaneous tissue. The fibres of the external sphincter should be exposed and the dissection continued up to and beyond the muco-cutaneous junction. With scissors undermine for a short distance the skin to the outer side of the incision A B.

Step 2.—On the opposite side of the anus make the incision C D and reflect the flap Y as in Step 1. Be careful that the distance between A and C and between B and D is fully one inch.

Step 3.—With scissors, undermine the bridges of skin A C, B D. Attend to hæmostasis.

Step 4.—Replace the flaps X and Y and suture the wounds A B and C D. Apply dressings. Sensation gradually returns in the area of operation.

Lockhart-Mummery (Brit. Med. Jour., Aug. 21, 1915) very strongly endorses Ball's operation.

III. *Lynch's operation* (Med. Record, June 13, 1914) is almost identical with Ball's except that the incision is only about ½ inch in length, and from it the skin is undermined from the anterior raphé to the posterior commissure within a radius of 1½ inches from the anus. Bleeding is controlled by pressure and the wound is drained for twelve hours by a small piece of rubber tissue. As a rule no sutures are required and the wound is healed in about forty-eight hours.

FISTULA IN ANO

Before describing the operative treatment of anal fistula it is important to nsider the anatomy of the disease and the principles on which proper opera- ons must be based.

If a line is drawn transversely through the middle of the anus, all fistulas ing anterior to this line will be found to pass directly from the cutaneous penings to that in the anal canal, whereas all fistulas posterior to this line ave their internal opening in the posterior midline of the anal canal no matter ow many external openings there may be and no matter where these external penings are situated. Thus practically all complicated horseshoe fistulas are osterior.

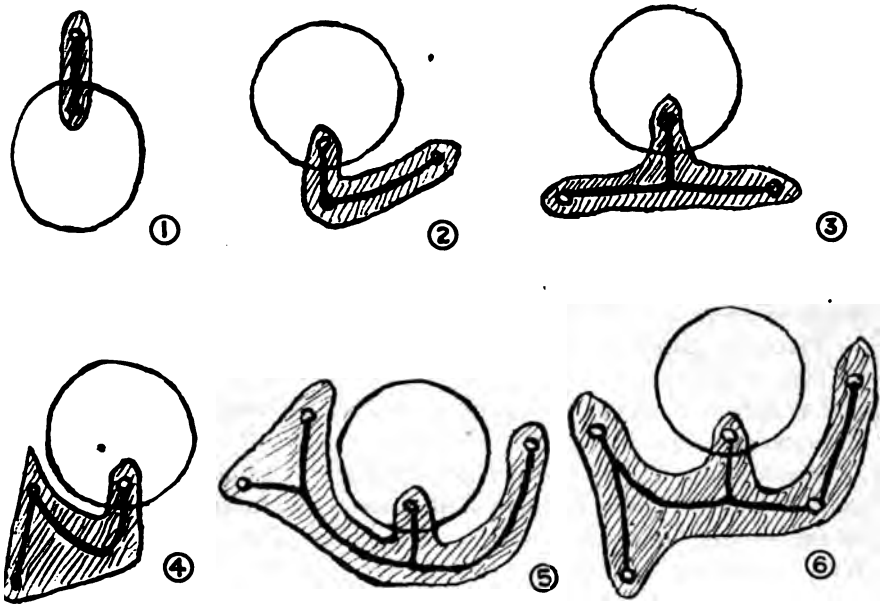


FIG. 668.

It is commonly believed that all except the most superficial fistulas run om the skin to the gut external to the internal sphincter, *i.e.*, that they enetrate between the external and the internal sphincters. It is generally elieved that division of the external sphincter is necessary to effect a cure not ly because of the free drainage secured, but because of the rest given to the ound while the muscle is *hors de combat*.

Goodlee found at autopsies that the majority of fistulas are superficial to e external sphincter and Mummery corroborated these findings by careful servation during operations. He writes "If, when operating for fistula, one ides the track to the internal opening by cutting down on to the director th an ordinary scalpel, instead of, as is more usual, transfixing it, it is quite y to observe whether or not one cuts the fibres of the external sphincter. ave been surprised to find in how few cases the muscle has been cut." With

very few exceptions the internal opening of any fistula is situated within three fourths inch of the skin margin. "The fact that a track can be detected running up the bowel for some considerable distance does not mean that the internal opening is at the upper end of this track; it will probably be found low down near the anus." (Mummery, Diseases of the Rectum, 1914.)

Prophylactic Treatment.—As fistula in ano is always caused by an abscess which opens into the rectum or discharges through the skin or by both routes, it follows that proper treatment of ischio-rectal abscess is the best preventative of fistulas. Whenever the existence of an ischio-rectal abscess is known or even believed to be present, make a free incision into the indurated tissue through the skin external to the sphincter. Do not injure the sphincter. The incision need not be radial to the anus. It should be placed where it will give the best drainage and be free enough to permit the easy insertion and retention of a drainage tube. The patient is to be congratulated if operation is performed before the indurated mass has broken down into frank pus. Do not pack the cavity with gauze as such acts as a plug. Apply dressings. Keep the parts clean. Let the patient sit in a hot bath morning and evening. During the remainder of the time he should be in bed. Do not irrigate the abscess cavity. Sometimes the use of hyperemia by Bier's cups is of value. If drainage is insufficient reopen and enlarge the opening. Always warn the patient of the possibility of subsequent fistula.

Operative Treatment of Fistula in Ano.—Never operate for the cure of fistula in the presence of acute inflammation or when there is much pus.

Place the patient in the lithotomy position after he has been prepared as for hemorrhoid operation.

(A) Simple complete fistula with nearly straight track between the external and internal openings.

Pass a grooved director completely through the fistula. Pass a finger into the gut and with it bring the point of the director out through the anus. Guided by the director divide all the tissues covering it. The fistula is now a gutter. With a sharp spoon scrape away all the granulation tissue lining the fistulous track. If there is much dense scar tissue surrounding the track incise this tissue. Such an incision is called "Salmon's back cut" and is very useful. Pare away any overhanging edges of skin. Attend to hemostasis. Fill the wound with a not too tight pack of gauze. The author generally employs gauze moistened with Paraffin or vaseline. Apply dressings. Keep the bowels locked for four or five days and then open them with a dose of castor oil. After the bowels are allowed to move, the dressings must be changed frequently and Sitz baths are comforting.

(B) *Complicated Fistula. Horse-shoe Fistula.*—It has been shown that most complicated fistulas are situated behind the anal equator and that no matter how many external openings and tracks may be present there is usually but one internal opening and that within ¾ inch of the anus.

Begin the operation by freely opening all the fistulous tracks except that which penetrates the gut. Only after this is done proceed to divide the track leading to the internal opening exactly as in simple fistula. Make the incision strictly radial to the anus. *Never* incise the anal margin obliquely *nor* in more

place, otherwise loss of control may result. Treat the tracks as in
le operation. Pare away all skin and tissue likely to interfere with
and healing (Fig. 668).

'istula with a Lateral Internal Opening above the External Sphincter.—
y writes "It is a matter for serious consideration in such cases whether
better to avoid dividing the external sphincter laterally, even at the
.e fistula not healing; a second operation being preferable to an incon
us. In some cases it is a good plan after division of the track to bring
of the sphincter together by deep traction sutures of silkworm gut
wire. By enlarging the opening of the fistula and draining the deep
ıe track with drainage tubes, one can usually obtain healing of a fistula
igh lateral internal opening without laying open the track into the
An operation in two stages is well
d to overcome the difficulties incident
:teric division.

FIG. 669.

a probe or director through the
Guided by the probe freely incise
lous tract but do *not* divide the
The whole tract must be freely
y division of the mucosa, etc., above
and of the skin external to the anus,
ınus itself and the sphincters are left
'ig. 669). Pack the whole wound.
thing goes well the whole fistulous
l heal except near the sphincter where a small sinus will be left. This
ıidual sinus or fistula is easily cured by dividing the sphincter which
quickly that no mass of scar tissue forms to interfere with its efficiency.
ı tracks exist running up under the mucous membrane such should *not*
:d but should be dilated and drained with tubing, rubber dam or strips

g ("Trans. Am. Surg. Assoc.," 1912) thinks that practically all anal
ommunicate with the intestine whether the point of communication
vered or not, and that if this communication be destroyed the fistulæ
ver under almost any or no treatment.

g's Method.—Demonstrate, if possible, the inner opening of the fistula.
ıe anus. Beginning at the muco-cutaneous junction excise the mucous
ıe, exactly as in the Whitehead operation, to a point above the fistulous
, if such is not seen, up to the white line which shows where the levatores
:he gut. Treat the wound as in the Whitehead operation. Curette the
tracts and drain them, making stab wounds for drainage if necessary.

l external fistulas have external but no internal openings. Enlarge the
opening by free incision without encroaching upon the anal margin.
way granulation tissue and excise any excess of scar tissue. Trim the
the wound. Pack with gauze. If the fistulous track reaches to the
membrane, that may be punctured with a director and the lesion
ıs a simple complete fistula.

l internal fistulas have internal but no external openings. Expose the

internal opening. A speculum may be necessary for this purpose. Introduce a director or probe through the fistula towards the skin. Using the probe as a guide convert the incomplete into a complete fistula. Complete the operation as for a complete fistula.

4. *Excision of Fistula.*—Incise the fistula (complete or incomplete) as already described. With forceps, scalpel and scissors remove, if possible en masse, *all* the sclerosed diseased tissues surrounding the fistula. Attend to hæmostasis. With sutures close the whole wound. This is best done by suturing in layers with a continuous suture of fine catgut. The first series of sutures should be confined to the deep wound and not touch either the mucosa or the skin; the two latter structures should be closed by separate superficial sutures. If the sutures closing the deep wound pass through the mucous membrane or skin, they are liable to conduct infection into the deep structures.

FIG. 670.—Thrailkill's probe.

Thrailkill excises fistulæ as follows: Pass the probe of the "safety-pin spring probe" through the fistula into the rectum; catch the end of the probe on to its hook (Fig. 670). Make an incision through the anal mucosa and the sphincter down to but not into the fistula. By taking hold of the handle of the instrument, the fistulous tract and wall can be firmly held while the diseased tissue, threaded on the probe, is dissected out in one piece.

Kenneth Mackenzie's Operation.—("Trans. Am. Surg. Assoc.," 1911.)

"1. The patient is prepared in the most careful way as for any major surgical operation on these parts.

"2. The sphincter is completely dilated.

"3. The internal orifice of the fistula is minutely examined and with a proper instrument is very cautiously dilated. After dilatation the mucosa is uplifted and pared with curved scissors in the direction of the long axis of the bowel, and with a small knife or fine scissors the circumference of the muscular layer is then trimmed and vivified. If need be, the opening may be incised or split in the direction of the circumference of the sphincter. After this has been done a few interrupted sutures of iodized catgut are introduced in the muscular layer at right angles with the sphincter, tied and divided. The mucous membrane is then sutured with interrupted chromic catgut or silk sutures, properly spaced. If more than one orifice exists, of course the same procedure is followed.

"4. A flap is made on the side involved, beginning by making a small semilunar incision just beyond the border of the external sphincter, dividing the parts down to the fistulous tract, the latter being divided flush at its point of emergence from the bowel (Fig. 671). The incision is extended from both ends of the first incision outward and made large and deep enough to include, if possible, under the eye all visible and accessible branching tracks. The exigencies of the case may require sometimes the lifting of one or other of the buttocks in its entirety. In one case, it was necessary to make a complete flap

artial resection of both buttocks in order to reach the deepest and most
ıt branching tracks.
. The opposite side of the rectal opening is now attacked, and after all
ful tissues have been removed the rectal walls are infolded once or twice
he line of suture within. The greatest care must be exercised in removing
ubtful tissues. If need be the cautery could be used for their complete
ıction, or substituted entirely for the suture of these parts.

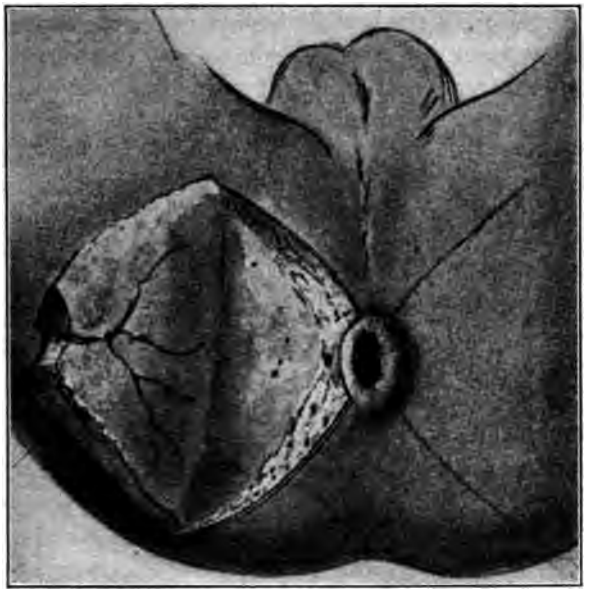


FIG. 671.—(*Kenneth Mackenzie.*)

'6. The exposed flap is next attacked with knife or large pointed scissors,
ed on the flat, and the original track, its branches and the entire fistulous
including every branching track resected. Careful search will be made in
schiorectal fossa and perirectal spaces for any concealed track.
'7. The whole field is then carefully flushed with normal salt solution and,
ed be, antisepticized and the fat layers sutured with buried catgut so as to
all dead spaces. In many cases the entire wound may be closed as in the
of breast amputation or a small drain may be left for twenty-four or forty-
hours."

CHAPTER XXXVIII

ASCITES

Ascites.—Ascites may be due to many causes, notably to cirrhosis of the liver. In this disease interference with the portal circulation is supposed to cause the ascites by damming back the blood coming from the abdominal viscera to the liver. Rolleston and Turner argue that ascites does not occur when the blood pressure is presumably highest in the portal vein, *i.e.*, early in the disease; that ligation of the portal vein does not necessarily cause ascites; that ascites is probably rather a result of a toxæmia than a mere mechanical result of increased blood pressure. These observers think that any good obtained by omentopexy is due (a) to a diminution of the blood flowing through the liver, permitting the liver cells to purify the blood passing through it more satisfactorily; (b) to an increase of the arterial supply of the liver, through new-formed adhesions, this increased nutrition to the liver cells favoring their compensatory hypertrophy.

Operations for ascites may be divided into two classes: I. Operations aiming at the prevention of the effusion of the fluid. II. Operations aiming at the removal of the effused fluid.

I. Morison-Talma Operation. Omentopexy. Epiplopexy.

Long ago it was noted that after repeated removals of ascitic fluid by means of the trocar and cannula, recovery occasionally took place. This recovery was ascribed to the passage of some of the portal blood into the systemic circulation through adhesions formed between the intra-abdominal viscera and the parietes. Talma and Rutherford Morison (the latter aided and abetted by Drummond) each independently decided to open the abdomen and in a definite fashion establish adhesions between the viscera and the parietes.

Step 1.—Open the abdomen near the middle line above the umbilicus. Encourage all the ascitic fluid to escape. Mop out the fluid from the pelvis and the renal pouches with gauze.

Step 2.—With gauze rub the upper surface of the liver vigorously enough to favor the formation of adhesions between it and the diaphragm. Do the same to the spleen.

Step 3.—*Method A.*—Pull the omentum into the wound and unite it to the anterior parietal peritoneum in the following manner: Evert one edge of the abdominal wound so as to expose the anterior parietal peritoneum to a point far from the middle line. This is easy because the belly-wall which was much distended by the ascites is now quite lax after the removal of the fluid.

Suture the edge of the omentum to the parietal peritoneum as far from the middle line as possible. Continue this suture until the middle line is reached. Do the same on both sides.

Method B.—After everting the anterior belly-wall as in Method A, make a transverse incision through the peritoneum and suture the edge of the omentum into this transverse wound.

Step 4.—Close the abdomen with or without drainage.

On the whole, the results of the Morison-Talma operation have been very r. The death rate has been high—approximately 20 per cent.—but one must member that any patient requiring the operation is at best "a bad risk." he best results have been obtained in patients operated on early; some of the sults have been most gratifying.

In the "American Journal of Surgery" (June, 1909) are published the llowing statistics of omentopexy and its modifications: 1565 cases; 30.4 er cent. cured; 19.8 per cent. relieved; 39.2 per cent. not relieved; 10.6 per cent. ied. "The greatest variation—5 to 23 per cent.—is in the percentage of eaths, and this is found to depend on the variation in the length of the post-perative period on which the different mortality statistics were based."

Bindi thinks that omentopexy not only produces new and free anatomical onnections between the portal and systemic circulation, but that it awakens nd increases the absorbent power of the peritoneum.

Maiochi reported seventeen cases of operation for cirrhosis (ascites) without eath due to operation. Some of the cases were observed for five years and our seemed to be cured of their symptoms.

Schiassi's Method.—"Schiassi makes a vertical incision a little below the ft costal margin opposite the middle of the clavicle, and another one running utwards from the upper end of the first incision. A triangular flap consisting f all the tissues to the peritoneum is then raised, and a vertical incision made n the peritoneum. The spleen and the great omentum are withdrawn sufficiently to allow the surgeon to fix them in the wound which is then sutured" Jacobson and Rowlands).

Mayo's Method.—Mayo makes an "incision on the right side over the liver, in line with the deep epigastric and internal mammary vessels, so as to explore its surface. A second incision is made four inches below this through the rectus muscle but not through it posterior sheath. The posterior sheath is extensively separated from the muscle and a portion of the omentum drawn out of the upper incision and, with a pair of forceps, pulled down into the pocket, bringing it directly in contact with the larger vessels. This can be repeated on the opposite side and the intervening segment attached to the whole front of the parietal peritoneum after the plan of Morison."

Narath's Method.—Narath has modified the Talma-Morison operation as follows ("Zentralblatt für Chir.," 1905, No. 32):

1. Under local anesthesia open the abdomen just above the umbilicus and to the left of the round ligament.

2. Thoroughly drain away the ascitic fluid from all dependent parts of the abdomen.

3. Pick up and pull out of the wound a large segment of omentum. This portion of omentum should be well provided with vessels and its pedicle should be as thick or thicker than a finger. The tension exerted on the omentum must not be so great as to disturb the position or motility of the transverse colon.

4. With sutures partially close the wound in the peritoneum and abdominal ascia, being careful not to cause pressure on the protruding omentum. With few fine sutures anchor the pedicle of omentum to the peritoneum.

5. By blunt dissection form a subcutaneous pocket to the left of the wound and into this pocket tuck the 4 or 5 inches of omentum which protrude through the belly-wall.

6. Close the cutaneous wound and apply dressings which will not injuriously press upon the omentum in its subcutaneous position.

Corson ("Annals Surg.," Dec., 1907) is an enthusiastic advocate of Narath's method. For reasons which will be given later the author believes this modification of omentopexy to be valuable.

A number of surgeons, notably Delageniere, advocate performing cholecystostomy in addition to omentopexy. *If* the patient's general condition justifies this additional step it is calculated to be of some value.

Encouraged by the success following omentopexy and believing that success to be due to the passage of blood from the portal to the systemic circulation through the omental adhesions, some surgeons sought for a more direct method of attaining the same end. The experiments of Eck showed the feasibility of establishing an anastomosis between the portal vein and the inferior vena cava. Tansini proposed applying this procedure to man and Vidal was the first to carry it out. Unfortunately, as Guibé writes, "this operation ought to be abandoned because, however efficient it may be, it exposes the patient to too great dangers—the danger of alimentary intoxication which might possibly be foreseen and avoided, but specially the danger of a general infection of intestinal origin, since the intestinal mucosa does not always oppose a sufficient barrier to microbic invasion. The patient operated on by Vidal died after four months with evident signs of a sudden general infection." A patient operated on by Thierry de Martel died of anuria in 48 hours. Villard and Tavernier anastomosed a mesenteric vein to the right ovarian, but the opening became occluded by a clot.

II. Operations for ascites aiming at the removal of the effused fluid.

Paracentesis Abdominalis.—The bowels and bladder have been emptied. Thoroughly cleanse the abdomen. Place the patient (unless too weak) in a sitting posture. Place a binder around the abdomen in such a manner that it can be continuously tightened by an assistant standing behind the patient. The binder must be provided with an opening in front through which the operation may be performed. Percuss the abdomen to find the limits of the contained fluid. Choose the site of operation, usually in the linea alba midway between the umbilicus and pubis. Anesthetize the skin by injecting a few drops of weak novocaine solution. Puncture the skin with a tenotome. Through the puncture insert a trocar and cannula of medium size. Withdraw the trocar. Permit the fluid to escape and as it escapes have the binder tightened. Should the patient show signs of faintness stop the flow of fluid until he recovers.

When all the fluid, or as much as seems proper, has been withdrawn, remove the cannula. A stitch to close the puncture may be necessary occasionally. Apply dressings. Keep a snugly fitting binder around the abdomen.

The author has prolonged life in certain cases by injecting into the subcutaneous tissues some of the fluid withdrawn exactly as in hypodermoclysis.

Permanent Abdominal Drainage.

Lambotte's Method.—Tie a large knot about 2½ inches from the end of a ick silk thread about 18 inches long. Make a small opening into the abdo- en; introduce the knot and short free end of the silk into the peritoneal cavity; ose the deep abdominal wound around the silk thread. (The knot in the ıread is to prevent the thread being pulled out of the abdomen.) With a ng probe push or pull the long end of the thread subcutaneously from the bdominal wound to about the middle of the thigh. In Lambotte's case there as great improvement by the fourth day. Marked œdema was noted along he course of the thread. Unfortunately the thread, becoming imbedded n the abdominal wall, no longer reached the peritoneum and thus the ascites eturned.

Handley has operated in a similar fashion ("Brit. Med. Journ.," April 16, 910). The abdomen was opened in the left semilunar line; "a stout needle hreaded double with lymphangioplasty silk was now passed in and out in a eries of loops through the peritoneal and subperitoneal tissues of the right liac fossa external to the mesocolon. Short loops of the silk were left exposed vithin the peritoneal cavity, whence they could suck up fluid by capillary at- raction. The process was repeated with two other threads. The four threads vere conducted in the manner described to a point close to the anterior superior pine. With the aid of a long probe they were then thrust beneath the outer end f Poupart's ligament some way downwards into the subcutaneous tissues f the thigh. The abdominal wound was now closed in such a way that the utures used proved additional permanent channels for the escape of fluid rom the peritoneal cavity. A number of thick silk ligatures were employed aking up the peritoneum and the muscular layers of the abdomen but leaving ut the skin. These were tied and the skin was then closed over them with a continuous superficial suture." The result of the operation was excellent. Œdema under the abdominal skin showed that the silk used in suturing was acting as desired, but the right leg and thigh so far from being œdematous were slightly smaller than the left. It seemed as if the silk threads passed into the thigh were useless. Seven months after operation a condition arose which seemed to show that these threads were useful and that drainage had been taking place all the time without causing evident œdema, and further that if the absorptive power of the tissues is normal and the amount of fluid led into them is not excessive, then œdema need not be expected.

Henschen ("Zent. für Chir.," Jan. 11, 1913) operates as follows: Make a semilunar incision (convexity posterior) through the skin above and external to the iliac spine; undermine the skin towards the base of the flap outlined. Opposite the base of the skin flap make a small incision through the aponeurosis and muscles at right angles to the direction of their fibers and thus form a tunnel about the size of a finger through the parietes. Open the peritoneum. With fine interrupted silk sutures stitch the thickened ring at the base of a rubber finger-cot to the peritoneum all round the incision in it. Cut away the blind end of the finger-cot at such a level as to leave the attached segment protruding about ¾ inch beyond the external aponeurosis. Suture the protruding end of the finger-cot circularly to the wound in the aponeurosis. Close the skin wound.

Henschen remarks that a similar method might be used to conduct ascitic into the loose lumbar retroperitoneal cellular tissue.

Peter Paterson (Lancet, Oct. 29, 1910) makes a small incision through the peritoneum and introduces a glass button. This button measures about 1 inch across the flanges, ¾ inch between the flanges and has a canal 1/12 inch wide. The flanges are about 1/16 inch thick. The length of the cylindrical part should vary in different buttons as this part must pass through the abdominal muscles. When in place one flanged surface lies inside the peritoneum and the other outside the muscles in the subcutaneous fat. Before placing the button in position any of the omentum which might plug the inner end of the button must be excised.

Drainage through the Femoral Canal.—Acting on a suggestion made by Wynter, Handley has opened the peritoneum through the femoral canal and sutured the edges of the peritoneal wound to the surrounding tissues in such a manner as to prevent its closure if possible. The skin wound is of course completely closed. The object of the operation is to conduct the ascitic fluid into the subcutaneous tissues of the thigh whence it may be absorbed.

Although femoral drainage gave at least one brilliant result, yet the new formed canal usually becomes closed or plugged and failure results.

Direct Drainage into Veins.—The vein suitable for use in this operation is the internal saphenous, for the following reasons: (1) It is conveniently situated; (2) it is large enough to permit of easy manipulation; (3) it is provided with efficient valves near its mouth (the operation is contraindicated when varicosity of the vein renders the valve useless); (4) it does not belong to the portal system.

As a preliminary to operation always make sure, by culture and inoculation, that the ascitic fluid is sterile. This is of *great importance.*

Step 1.—Make an incision in the inguinal region along the course of the internal saphenous vein. Expose and liberate the vein from its junction with the femoral downwards for about 4 inches, *i.e.*, free enough of the vein to reach, *without tension*, a point on the abdomen just above Poupart's ligament.

Divide the vein at the selected point and ligate the peripheral segment.

Step 2.—Wash away blood from the vein with warm salt solution. Smear the cut end of the vein with vaseline and protect the vein from drying.

Step 3.—Open the abdomen a short distance above Poupart's ligament preferably by means of the muscle-splitting method. With closed forceps make a subcutaneous tunnel from the incision in the groin to the abdominal incision. Pass the mobilized segment of vein through the tunnel and suture its open end to the opening in the peritoneum. This suturing ought to be done after the Carrel method of arteriorraphy, with vaselinized silk.

Step 4.—Close the wounds. Before closing the abdominal wound it may be necessary to divide a few muscle fibres so as to prevent pinching of the vein as it passes through the parietes.

Routte ("Lyon Chirurgical," March, 1910; "La Presse Med.," June 25, 1910) performed this operation in January, 1907, on a very unfavorable subject. For a month everything went well but after that time Routte performed the operation on the opposite side and the patient died three days later from grave cardiac disease.

Routte's second patient was a man of seventy. The operation was performed on both sides at the same sitting. The patient remained apparently well for over eighteen months after which time he was lost to sight.

Out of five patients operated on by Routte, in two the result was negative; that of three operated on by Ito and Soyesima there was but one success, but that was secured in a man of thirty-eight who had been tapped seven times, been subjected successively to omentopexy, renal decortication and to an attempt at drainage into the subcutaneous tissues by means of a buried cannula.

Remarks.—Operations which promise even a very moderate amount of success are thoroughly justifiable in such a fatal condition as ascites due to hepatic cirrhosis.

The patients are usually in such poor condition that they are incapable of withstanding any severe intervention.

Narath's modification of omentopexy seems superior to the Talma-Morison operation in that it probably establishes a permanent and efficient drainage of the ascitic fluid into the subcutaneous tissues by means of the herniated omentum.

Wynter's remarks quoted by Handley are very weighty:

"The treatment of ascites by repeated paracentesis, commonly employed in hepatic cirrhosis, has proved unsatisfactory, inasmuch as in the majority of cases the fluid returns within a few days, and the patient is confined to bed in hospital for the remaining brief period of life, which seldom extends beyond two or three months.

"The steady downhill course and rapid loss of strength after paracentesis has been inaugurated indicate that the patient pays dearly for the relief of distention by the sacrifice of so much nutrient fluid, whose speedy replacement drains the blood and tissue and starves the kidneys. The objects aimed at by the method of subcutaneous drainage are:

"1. The saving of nutrient material to the patient.

"2. To ensure an adequate outflow of urine from the kidneys and a sufficient supply of fluid to the tissues by draining the stagnant pond of the peritoneal cavity.

"3. To enable the patient to leave his bed and to maintain the circulation of the body fluids, especially in the portal and lymphatic systems, by means of exercise.

"4. To relieve intraabdominal tension, and thus promote lymphatic absorption and the establishment of a good collateral circulation."

To the author it appears that much of the good obtained from omentopexy may be attributed to permanent drainage accidentally established; that some form of subcutaneous drainage will prove the treatment of choice; that all endeavors after direct anastomosis between the hepatic and systemic circulations are unjustifiable.

CHAPTER XXXIX

RETRO-PERITONEAL NEOPLASMS

Solid retro-peritoneal tumors may be lipomata or sarcomata. The method of operating is the same for both classes of tumor though when sarcoma can be definitely recognized after opening the abdomen it is hardly worth while to endeavor to remove it, unless in an attempt to relieve distressing symptoms. The mortality after removal of lipomata has been high because of the late stage in which operation has been undertaken.

In operating it is well to remember that retro-peritoneal lipomata arise principally from the peritoneal and the mesenteric fat. They may be of enormous size.

B. J. Johnston (of Belfast) in 1905 removed easily and apparently completely, a lipoma weighing 21 pounds from beside the right kidney. After two years he removed one of 12½ pounds from the same site in the same patient. There was no evidence of malignancy. George Ben Johnston (Journ. A. M. A., Oct. 22, 1914) reports two cases of retro-peritoneal lipoma operated on by himself and gives a good review of the literature.

Retro-peritoneal tumors in their growth necessarily push the intestines in front of them or to one side; if they arise near the base of a mesentery they grow into the mesentery, the vessels of which become spread over them; they can surround important structures such as the kidneys, the inferior vena cava, etc.; they may contract adhesions with their surroundings so that removal becomes difficult or impossible or they may be easily shelled out of their bed. Diagnosis is rarely made before operation, the condition presents itself to the surgeon as a surprise when he has opened the abdomen for exploration or on an erroneous diagnosis.

The rules to be observed in operating are: (1) Secure free exposure so as to judge if it is justifiable to attempt removal and, if removal is attempted, to do the operation as far as possible under guidance of the eye. (2) Divide the peritoneum covering the growth sufficiently to secure free exposure but in such a manner as to avoid injury to the intestines or their blood supply. If the nutrition of a segment of intestine is cut off, that portion of gut must of course be removed. (3) In separating the tumor from such structures as the inferior vena cava or the iliac veins, rather leave a portion of the tumor *in situ* than hazard their integrity. If it is impossible or improper to avoid injury to very large and important veins their wounds must be sutured at once *secundum artem*. (4) If a kidney is included in the growth and is not readily separated it may be well to remove it always provided that the opposite kidney is intact.

The following description of an operation by Fritz König (Berliner Med. Woch., 1900, No. 28) is instructive as a type "the peritoneal cavity was opened above the navel through a median incision which extended from the ensiform to the pubis, but neither omentum nor intestine could be seen as they were displaced upwards into a small cavity. The posterior parietal peritoneum lay before us, pushed far forwards by a yellowish tumor. The reflection of the

posterior peritoneum on to the anterior parietes formed a fold about a hands-breadth below the umbilicus. The posterior peritoneum was incised in the direction of the external wound and as the lobulated tumor seemed to be a lipoma its extirpation was begun. Vessels, especially mesenteric vessels did not seem to run deeply in the interlobular clefts. The tumor was firmly attached posteriorly and seemed to arise from the pelvis. The peritoneum which covered only the upper third of the tumor, was separated with difficulty; sharp and blunt lateral reflection of the soft parts covering the lower portions of the tumor was likewise difficult. During the enucleation much effort was required to lift the enormous tumor away from the posterior abdominal wall. The urinary bladder was not seen nor could one feel a catheter which had been introduced into it. During the dissection of the right posterior part of the growth a band was found passing backwards between two of its lobes. On division this was found to be the median ligament of the bladder dragged there by the bladder which lay behind the tumor.

On the left side the iliac veins were so united to the tumor and its capsule that they required to be freed by sharp dissection. The left vas deferens (leading to an atrophied inguinal testis) was so surrounded by neoplasms that it had to be divided. On the right side the vas and blood-vessels were not involved. . . . The tumor was removed in one piece except for a few fragments left attached to the left iliac veins. During the excision a vein deep in the pelvis was lacerated but lateral ligation of its wall was effective. In the enormous wound the bladder lay to the right of the pelvis in the sacral cavity, to the left was the rectum and above were the retro-peritoneal tissues. The rapid filling of the dilated veins especially about the cæcum was very striking in a peritoneal cavity which had been compressed into a very small space." The peritoneum was sutured but the pelvic cavity was packed with iodoform gauze.

Retro-peritoneal Cysts.—Dermoid cysts from an operative standpoint may be considered in the same class as lipomata while hydatids ought to be treated in much the same fashion as those of the liver. The other forms of retro-peritoneal cysts appear in literature under various names such as pancreatic, pseudo-pancreatic, renal, mesenteric, etc., etc. Dowd (Annals Surg., xxxii, 515) believes that many of the cysts published as "chylous," "sanguineous" etc., arise from sequestrations from the primitive organs of generation. Donoghue (Journ. A. M. A., Dec. 22, 1906) has similar views. In International Clinics iv, 1906, the author wrote, "In the literature on cysts of the lesser peritoneum one finds few reported, apart from those credited to the pancreas; it is often so difficult, or even impossible, to recognize during operation the precise origin of any individual cyst; there are so many possible sources from which cysts may develop that one is forced to believe that operators and writers have too often assumed their pancreatic origin without sufficient diagnostic data." The operative treatment of retro-peritoneal cysts varies according to circumstances. If the cyst lies behind the ascending or descending colon it ought to be approached through an incision in the parietal peritoneum just external to the colon, in fact through such an incision as is used in mobilizing the colon in colectomy. If the cyst occupies the lesser peritoneal cavity (pseudo-pancreatic cyst) it may be approached through the gastro-colic omentum; if it lies in a

mesentery it must be approached through the peritoneum of the mesentery, very great care being taken to incise as far from the gut as is possible and to avoid injury to the mesenteric vessels for fear of jeopardizing the nutrition of the gut. Once the cyst wall is exposed two methods of treatment may be available. (*a*) If it is easy to separate the cyst wall from its surroundings, with or without evacuation of its contents, do so. Usually the cavity left is at once obliterated by the collapse of its sides, otherwise it may be necessary to insert a drain. With sutures, close any peritoneal wound. (*b*) If enucleation of the cyst seems difficult or threatens the integrity of some important structure, make an opening into the cyst and evacuate its contents. Remove as much of the cyst wall as possible but leave enough to permit of its suture to the abdominal wall without tension. Suture the edges of the wound in the cyst to the parietal peritoneum and deep aponeurosis. (When the cyst is situated in the flanks it may be better to secure the marsupialization through a postero-lateral incision and to close the original abdominal wound.) Sometimes after its contents have been evacuated, a cyst which appeared impossible of enucleation may become removable.

If it is impossible or improper to bring the cyst into contact with the abdominal wound place a purse-string suture of catgut around the opening in the cyst, introduce a drain, tighten the purse-string round the drain and with a needle fasten the end of the suture to the tube so that the latter cannot escape before the catgut is absorbed. Bring the end of the tube through the abdominal wound. The technique of drainage in these cysts is very similar to that in cholecystostomy and the results are very good.

If a loop of intestine is inseparably attached to the cyst the two must be removed together.

Pakowski (Internat. Abst., Feb., 1913) extirpated dermoid cysts in 13 cases with 11 rapid recoveries. In 43 cases of dermoids collected by him the site of the tumors was as follows: great omentum 7; lesser omentum 1; lesser peritoneal cavity 3; mesocæcum 1; ascending mesocolon 2; transverse mesocolon 5; descending mesocolon 1; meso-sigmoid 3; in neighborhood of rectum 8; retroperitoneum 12.

CHAPTER XL

THE PANCREAS

The pancreas is so deeply hidden behind the abdominal cavity that it has been much neglected by the pathological anatomists. The fact that, when it is injured, other organs are always notably injured at the same time, and the patient is evidently in a critical condition, has led operators to neglect direct investigation or inspection of the gland. Until very recently the only pancreatic lesions attacked by surgery were cysts. To-day, thanks to the labors of many pathologists, internists, and surgeons, more knowledge has been attained and this "hermit kingdom" is being opened up to surgical therapy.

The pancreas reaches from the duodenum to the spleen and discharges its secretions through the canal of Wirsung into the duodenum. Before entering

the canal of Wirsung unites with the common bile-duct to form the ılum or ampulla of Vater (Fig. 672). Besides the main duct or canal ıng, there is a secondary duct (duct of Santorini), which arises from the ıct near the head of the gland and discharges into the duodenum at a higher level. The tail or left extremity of the pancreas lies in front of t kidney and the suprarenal capsule. The most important vascular ıs of the pancreas are the splenic artery on its upper surface, while at its the pancreatico-duodenal artery, which forms an arch with the superior eric. The pancreas lies behind the posterior parietal peritoneum and in

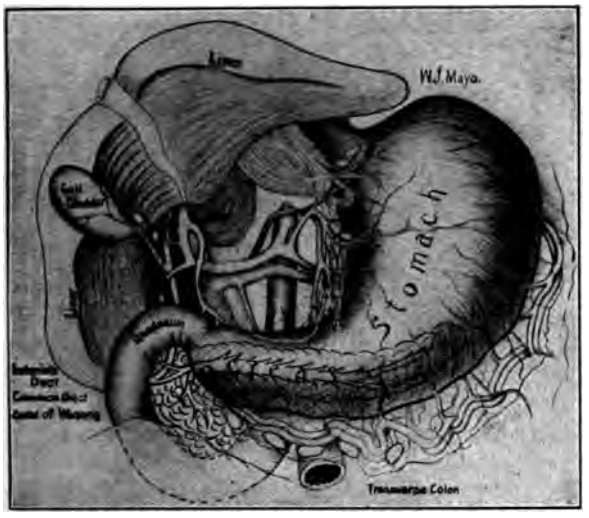


FIG. 672.—Anatomical relations of the pancreas. (*Mayo.*)

t of the lower portion of its head is the transverse mesocolon; in front of its y is the stomach.

There are several routes by which the pancreas may be reached: (1) Through gastro-hepatic omentum above the stomach; (2) through the gastro-colic ntum below the stomach; (3) through the transverse mesocolon back of n and the stomach; (4) by retracting inwards the second part of the duo- um; (5) through the stomach; (6) from the loin behind the peritoneum.

Operation upon a pancreatic cyst forms a good type on which to base a cription of surgical interference.

Step 1.—Open the abdomen in or near the middle line above the umbilicus. he cyst makes a prominent swelling, it may be well to make the incision, tically, over its most prominent part. Explore the abdomen, note the pres- e and extent of adhesions, and where the cyst presents. This may be ve, behind or below the stomach, behind or below the transverse colon gs. 673, 674, 675, 676, 677).

Step 2.—(A) The cyst presents or is most prominent above or behind the mach. Make a vertical tear through the gastro-hepatic omentum; this at ce exposes the cyst. Endeavor to explore the relations of the cyst, but do

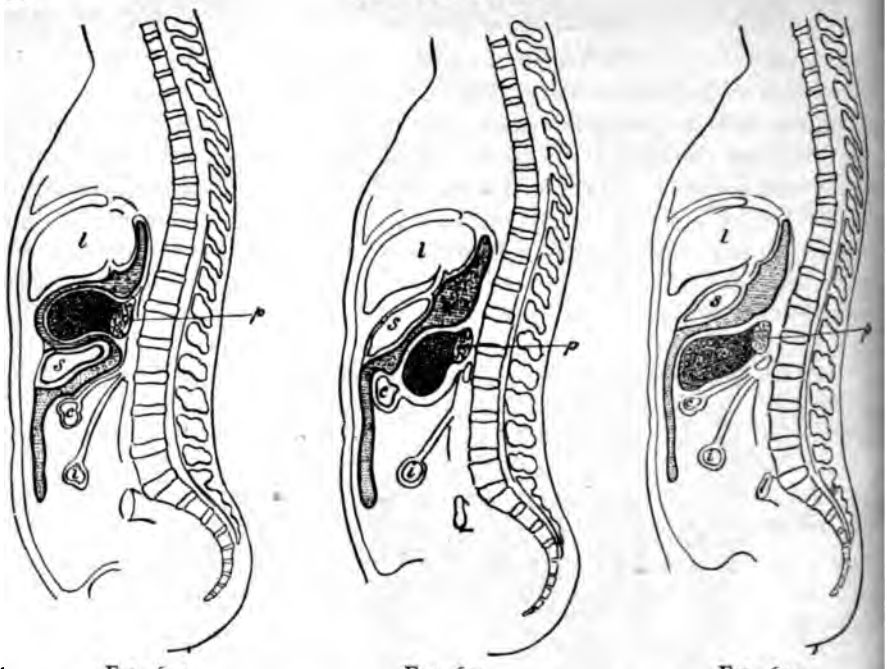


FIG. 673. FIG. 674. FIG. 675.

FIG. 673.—Tumor of pancreas. Stomach and colon both below it. (*Robson and Moynihan.*)

FIG. 674.—Tumor of pancreas. Stomach and colon both in front of it. (*Robson and Moynihan.*)

FIG. 675.—Tumor of pancreas pushing forwards between the posterior layer of the great omentum and the transverse mesocolon. Stomach above, colon beneath it. (*Robson and Moynihan.*)

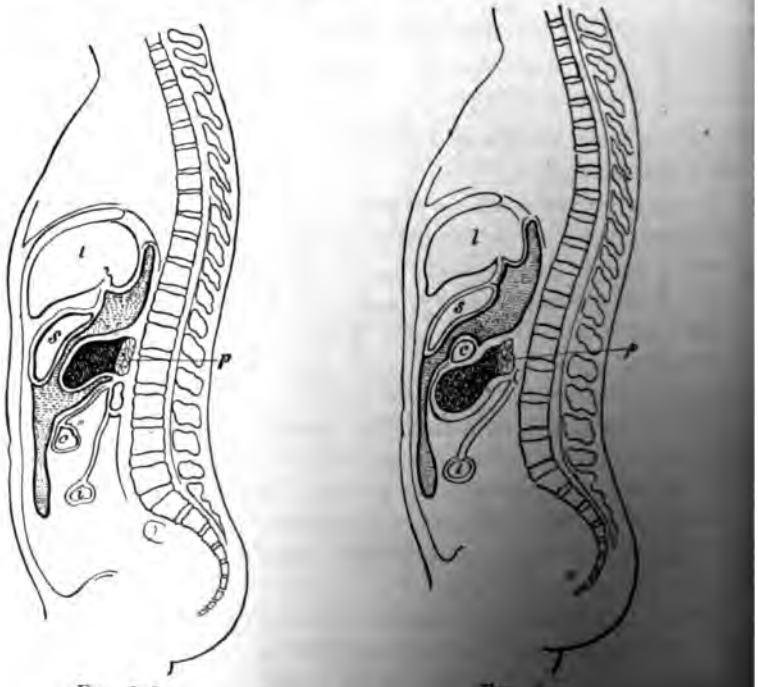


FIG. 676. FIG. 677.

FIG. 676.—Tumor of pancreas. Stomach in front, colon [illegible] *Moynihan.*)

FIG. 677.—Tumor of pancreas. Stom[illegible] *Moynihan.*)

rsist in the exploration if great difficulties arise, lest harm result. In a stances it may be found possible to excise the disease; most commonly ɔialization is the operation of choice.

The cyst presents between the stomach and transverse colon, behind lon, or behind the stomach. Make a vertical tear through the gastro-mentum and expose, explore, and treat the cyst. J. D. Malcolm ("Lan-une 16, 1906) completely and successfully removed a multilocular cystic through this route. Both layers of the transverse mesocolon were l; the wound in the inferior layer was sutured. Although the pancreas ras incised this gave no subsequent trouble, probably because drainage tablished posteriorly below the twelfth rib. Acute flexion at the splenic ɔf the colon necessitated colo-colic anastomosis on the sixteenth day after mary operation. Recovery.

The cyst presents behind or below the transverse colon. Pull the erse colon and great omentum out through the belly wound and turn ɹpwards exactly as is done in posterior gastro-enterostomy. In an avas-rea of the transverse mesocolon make an appropriate tear and expose, ex-ɪnd treat the cyst. Do not injure the mid-colic artery or any of its main es.

Körte has reached the head of the pancreas by forcing his way along e of the duodenum after incising its peritoneal covering. This is very to Vautrin's method of reaching the lowest segments of the common ct.

ɪchet (Sherwood-Dunn, Am. Jour. of Surg., Oct., 1916) has exposed the as satisfactorily through the intercolo epiploic route (p. 404).

Transgastric route: Hagen ("Archiv f. klin. Chir.," lxii, 157) reports in which complications compelled him to attack the cyst after incision ɪ the anterior and posterior gastric walls. The stomach was inseparably ɪdistinguishably adherent to the cyst. It was impossible to reach the nd bring a portion of its wall to the parietes by any ordinary means. made a two-inch incision through the anterior wall of the stomach and l one through the posterior wall. There was no line of demarcation be-the stomach and cyst-walls. After evacuation of the contents the cyst plored with the finger. It was possible with care to bring a small area t-wall to the parietes, to the left of the great curvature, below the ribs, l the left gastro-epiploic artery and vein. Before the selected portion of all could be united to the parietes it was necessary to resect the cartilages ninth and tenth ribs on the left side; this permitted the soft belly-wall t inwards and meet the cyst-wall as it was elevated. Closure of the gas-ɔund by suture and marsupialization of the cyst completed the operation. ery. Hagen considered the possibility of lumbar drainage, but in his was out of the question.

Lumbar route: Remember that the tail of the pancreas lies in front of t renal vessels, hence any operation by which the hilus of the kidney is d will also give access to the left extremity of the pancreas. Exposure kidney through the loin is so fully discussed elsewhere, and exposure of l of the pancreas is so similar, that further description is unnecessary here.

In the course of transperitoneal operations it is often advisable or necessary to provide lumbar drainage. To effect this, explore the cyst with the finger; guided by the finger and carefully avoiding all important structures such as the renal vessels, etc., push a closed forceps through the posterior parietes below the twelfth rib and immediately external to the erector spinæ muscle. Incise the skin and deep fascia at the point made prominent by the forceps. Make the opening large enough to avoid compression of the tube or gauze used for drainage. With the forceps pull a drain (gauze or tube) into position. It is well, when preparing a patient for any operation on the upper half of the belly, in which posterior drainage may be required, to follow Park's advice, and clean the lumbar region as well as the abdomen; thus valuable time may be saved in the course of the operation. Deaver's plate (Fig. 678), although drawn to illustrate the relations of the kidney, illustrates the important anatomical rela-

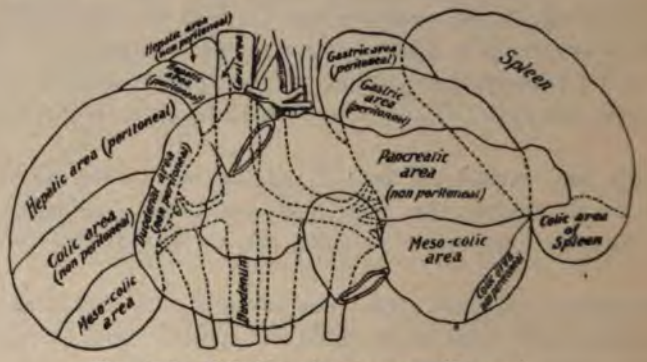


FIG. 678.—Relation of pancreas. (*Denver.*)

tions of the pancreas, especially with regard to exposure through the lumbar route. Only the head and tail of the pancreas are accessible by this posterior route, the tail being more easily reached than the head. Peters was successful in exposing and draining a hydatid cyst of the tail of the pancreas through the left lumbar route.

Step 3.—Treatment of the cyst. Dangers: The dangers inseparable from operations on the pancreas are less pronounced in cystic than in other diseases or lesions. It will be convenient, however, at this time, to discuss the dangers of pancreatic operations in general; v. Mikulicz gives a good résumé of these in his paper on "The Surgery of Trauma and Inflammatory Processes in the Pancreas" ("Transactions of the Congress of American Physicians and Surgeons," 1903).

1. Hemorrhage. The pancreas is exceedingly vascular; its tissues are fragile, and hence simple ligature is often entirely ineffective. Sutures involving a mass of healthy or uninjured tissue, as well as the bleeding area, are necessary in spite of the dangers from necrosis incident to the use of mass ligatures. Secondary hemorrhage is common. It is wise, when possible, to prepare the patient, prior to operation, by the exhibition of large doses of chloride of calcium, as recommended by Mayo Robson in cases of jaundice.

2. Leakage of pancreatic juice into the parenchyma of the gland and the

rrounding peritoneal structures constitutes a greater danger even than bleed-
g. The juice, even when sterile, does much positive damage; it also dimin-
es the resisting power of the tissues so that the mildest form of infection,
dinarily harmless, becomes of the gravest significance. Infection is liable
reach the injured area through the pancreatic duct from the duodenum in the
me manner as it passes up the common bile-duct. Fat necrosis and pancrea-
tis, both chronic and hemorrhagic, may be occasioned by trauma, and hence
ay result from operation. Peritonitis is very liable to result from pancreatic
akage. This peritonitis may be aseptic and is frequently followed by intesti-
l paralysis, leading to rapidly developing obstruction, which often so modifies
e symptoms as to lead to a serious mistake in diagnosis (v. Mikulicz). During
cision of gastric cancer portions of the adherent pancreas may be shaved away,
emostasis being attained by sutures and by covering the wound with perito-
eum. The fact does not negative the value of the preceding remarks as in
stric cancer where portions of the pancreas must be sacrificed, these portions
ve been subjected to simple or adhesive inflammation and thus are prepared
r operation.

3. It has been shown that by the time such definite symptoms of pancreatic
sease arise as diabetes or severe disturbance of its fat-digesting function,
ere is, as a rule, already such great destruction of its substance that surgical
terference is not admissible. The author operated on one case of very
cent pancreatic diabetes in the hope that drainage might relieve the inflam-
ation to which it was believed the disease was due; the patient did not sur-
ve more than twenty-four hours. Nash ("Lancet," Nov. 1, 1902) reports a
se of pancreatic glycosuria associated with cholelithiasis in a man of sixty years.
fter removal of a large calculus from the gall-bladder, recovery ensued. The
rine four months after operation was free from sugar. In Woolsey's three
ccessful operations for acute pancreatitis only one had glycosuria.

Mayo Robson ("Brit. Med. Journ.," April 23, 1910) after discussing the
alue of Cammidge's reaction as a means of diagnosing pancreatic disease before
nd after the appearance of glycosuria, comes to the following conclusions:

1. That the early recognition and treatment of interstitial pancreatitis, or
pancreatic catarrh, by drainage of the bile-ducts, and thus indirectly of the
ancreatic ducts, and the removal of the cause, whether that be gall-stones,
uodenal ulcer, or other conditions, may be the means of averting diabetes.

2. That in certain diseases of the pancreas, even after the appearance of
lycosuria, surgical treatment is well worth considering, as in a number of cases
has lead to a complete disappearance of sugar from the urine, and in others to
n arrest of the disease causing glycosuria.

3. That every case of diabetes should be considered from its etiological
oint of view, seeing that certain cases of glycosuria of pancreatic origin are cur-
ble, and in others the progress of the disease may be arrested by suitable surgi-
al methods that can be carried out with small risk.

Robson reports a number of cases which support these conclusions.

(A) *Excision of the Cyst.*—This operation is suitable only in cases where ad-
sions are few or where the cyst has become pedunculated. Ransohoff has
llected 23 cases of enucleation with 2 deaths. The operation requires no

special description, as the surgeon must follow the common principles of surgery after the tumor has been exposed by one of the methods described above. v. Mikulicz lays down the absolute rule that whenever the pancreatic tissue has been exposed, drainage is requisite.

(B) *Marsupialization or Drainage.*—Expose the cyst by any of the methods described. Protect the peritoneal cavity thoroughly with pads. Note the part of the cyst which can be most readily brought into apposition with the abdominal wall. If the site of the primary abdominal incision proves unsuitable, a secondary incision may be made. If the cyst is very tense, empty it, at least in part, by means of the aspirator. Suture the cyst-wall to the parietal peritoneum. Explore the cyst cavity. Especially note if the tumor is a true pancreatic cyst, *i.e.*, one arising in the gland itself; or a false one, *i.e.*, a collection of fluid in the lesser peritoneal cavity due, as a rule, to injury or disease of the pancreas. If necessary, provide drainage by means of lumbar puncture. Provide tubular or gauze drainage of the cyst or a combination of tubular and gauze drainage. If the cyst-wall is of suitable consistency, it is well to fix a "dressed drainage-tube" into it, exactly as is done in the case of the gall-bladder. If the cyst-wall is too thin to be sutured with safety to the parietes or if it cannot be brought to the abdominal wound, protect the peritoneum with gauze packing around a tube which leads into the cyst. As a whole, the methods of draining pancreatic cysts are identical with those for draining the gall-bladder, but in the case of the former greater danger is to be feared from the effects of the leakage of fluid into the peritoneum. Having provided for drainage, close the excess of wound in the abdominal wall.

Usually, under the above treatment, the cyst shrinks and becomes obliterated. Occasionally a fistula persists.

Wohlgemuth and Karewsky have found that persistent pancreatic fistulæ close promptly when the patients are put on rigid antidiabetic diet. Walter Schmidt ("Muench. med. Woch.," Dec. 10, 1907) reports having excised a pancreatic cyst: the gland was injured, drainage provided, antidiabetic diet was ordered; everything went well until, on the thirteenth day after operation, a more liberal diet was permitted when the discharges became more profuse and continued so until the rigorous diet was reëstablished.

Solid tumors of the pancreas are rarely suitable for operation. Ruggi, in 1890, and Gade, in 1895, successfully removed tumors from the tail of the pancreas; most of the other cases reported promptly died.

Excision of the Head of the Pancreas.—The author is unaware of any operation actually performed for the excision of the head of the pancreas and the duodenum, but the steps of the operation as elaborated, on the cadaver, by Desjardins ("Rev. de. Chir.," June, 1907) teach so many valuable lessons that the method demands attention. Various items of the operation are well calculated to assist a surgeon when attacking such conditions as malignant disease of the duodenum near the ampulla of Vater, etc. Desjardins remarks that if the length and complexity of the operation demands it, the procedure may be carried out in two sittings. At the first sitting a gastro-enterostomy (en Y) is done, the jejunum being divided lower than usual, about 8 inches from its origin. At the second sitting the head of the pancreas is removed along with

duodenum and the double anastomosis of the bile-duct and the pancreas ried out. This second operation consumes about the same time as does an linary pylorectomy.

Desjardins' Operation.—There are three special anatomical dangers to be ercome in the operation:

a. In certain cases the upper end of the ascending colon lies directly on the ght surface of the descending duodenum and is hence in danger of injury when e duodenum is being mobilized.

b. At the third portion of the duodenum the superior mesenteric artery d vein emerge from under the lower edge of the pancreas and pass over the ont of the duodenum. The middle colic artery arises from the superior mesenric and courses through the transverse mesocolon; it is easily injured and inry leads to gangrene of the gut it supplies. The mesenteric artery, lying to the ft of its companion vein, is situated in the groove which separates the body om the neck of the pancreas; it runs downwards and to the right in a curve hich is convex towards the left; from its concave or right side as soon as it erges from the pancreas it gives off the colic arteries. To the left of the perior mesenteric vessels there is an avascular region in which there is no sel except the pancreatico-duodenal, and it can be safely tied.

c. Behind the pancreas and close to it, lie the portal vein and the inferior a cava.

Place the patient in Robson's position.

Step 1.—Make a median incision from a point on the level of the tip of the th rib, downwards to near the umbilicus. From the upper end of the vertical ision cut upwards and to the right, through the right rectus, until the costal rgin is reached above and to the inner side of the gall-bladder. If more m is required make an oblique cut downwards and to the left from the er end of the median incision. Before making the two supplementary s, introduce the hand and explore the belly.

Step 2.—Push the omentum to the left. Expose the duodenum. Incise the itoneum parallel to and about ¾ inch from the descending duodenum r noting that it is not adherent to the ascending colon. Through the perial wound separate the duodenum from the posterior belly-wall until portal vein and vena cava are passed. The head of the pancreas can now completely explored and even brought almost out of the wound.

Step 3.—Ligate the pyloric and gastroduodenal vessels as in pylorectomy. ide, between ligatures, the right portion of the great omentum.

Step 4.—Doubly clamp and divide the pylorus (Fig. 679). Pull the mod duodenum downwards to expose the common bile-duct. If the duct is d divide it, between forceps, as low as possible; if not dilated, divide it below the entrance of the cystic duct. At this stage it may be necessary tiously dissect the mesocolon in order to disengage the portion of the duo- lying under it. Continue the separation of the duodenum until the r mesenteric vessels are passed and the duodeno-jejunal junction is d; doubly clamp and divide the gut here.

p 5.—The pancreas and duodenum are still attached to each other. a clamp on the body of the pancreas (Fig. 679). The clamp must be

directed obliquely upwards and to the right so as to avoid injuring the c arteries. When so placed, the lower ends of the clamps are remote from mesentery where the colic vessels arise. Divide the pancreas to the right of clamp or between the clamps if two have been used (Fig. 680).

Step 6.—Remove the head of the pancreas and the duodenum being ca not to injure the mesenteric vessels which emerge from between these structu

Step 7.—Close the opening in the stomach where the pylorus was divi With a Murphy button anastomose the open end of the jejunum to the post surface of the stomach.

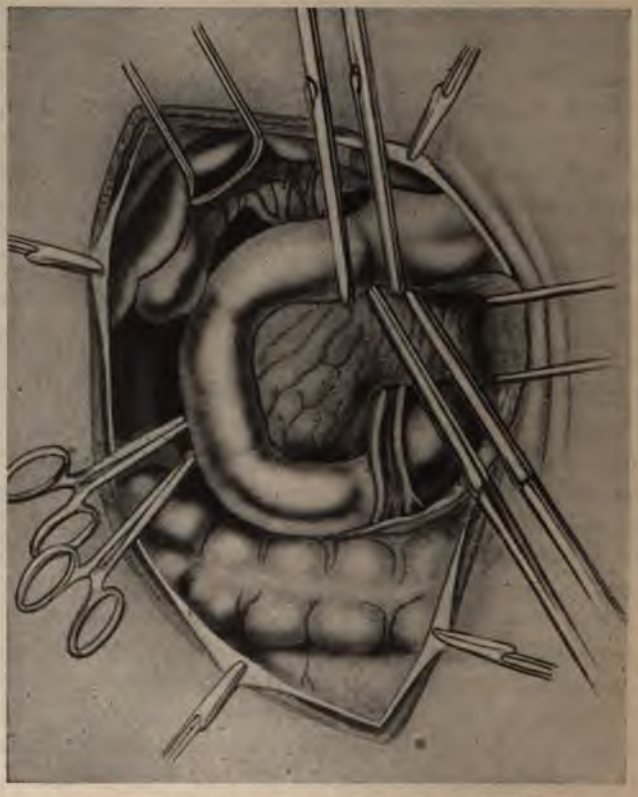


FIG. 679.—Excision of head of pancreas. (*Desjardin.*)

Step 8.—Anastomose the common bile-duct to the jejunum. If th impossible because of the small size of the duct, close the duct and anastor the gall-bladder to the jejunum.

Step 9.—Apply chain sutures to the cut surface of the pancreas but le the canal of Wirsung free. Isolate about 1 inch of the canal, and anastom it to the jejunum. This anastomosis is very similar to that between ureter and the bladder. If Wirsung's duct is too narrow to permit anastomosis another method must be adopted; often a number of small du will be found instead of one; this also demands a change in method.

Alternative Method.—Doubly clamp and divide the jejunum about 12 inches from its origin. Opposite the point of section free and divide the mesentery as much as possible without damaging the blood supply. Anastomose the distal segment of gut to the stomach as in Step 7. A loop of jejunum now lies free except for a loose mesenteric attachment, and open at both ends. Anastomose one end of this loop to the gall-bladder after closing the common duct; into the other open end of the segregated loop, push the divided end of the pancreas and fix it there by sutures introduced as nearly as possible in the Lembert fashion. Make an anastomosis between the middle of the

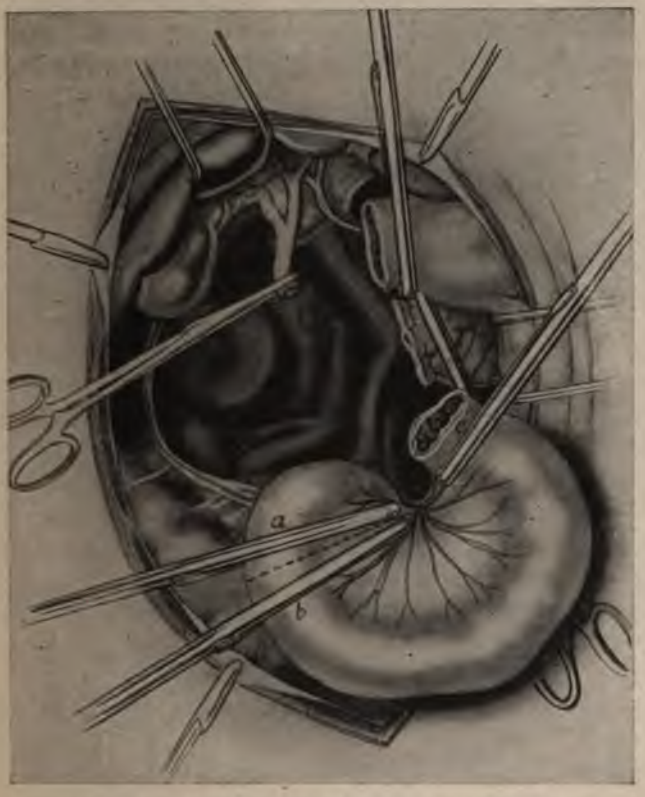


FIG. 680.—Excision head of pancreas. (*Desjardin.*)

segregated loop of jejunum and that portion which is anastomosed to the stomach. Provide free drainage especially in the pancreatic region.

Acute Pancreatitis.—The tendency at the present time is to operate very early in this most fatal disease. Deaver notes that few patients come under the surgeons care until the second or third day of the disease and that under these circumstances, as in other cases of diffuse peritonitis it is sometimes safer to encourage localization of the process before instituting drainage. This does not mean encouraging delay until the patient is moribund from sepsis. If a case is seen before symptoms of diffuse peritonitis arise no time should be lost

before operation is undertaken. The operation consists in an exploratory incision above the umbilicus. In doing this, be on the lookout for patches of fat necrosis; these are yellowish-white patches of various sizes situated in the subperitoneal, mesenteric and omental fatty tissues. Fat necrosis is always indicative of pancreatic disease.

According to indications found after the abdomen has been opened, the pancreas should be exposed either through the great omentum above the colon, or through the transverse mesocolon. The belly cavity must be thoroughly protected by gauze packing. If abscess is present, the pus is now evacuated, if requisite, incision being made into the pancreas for this purpose (case of Dr. C. B. Porter of Boston, reported by v. Mikulicz, "Trans. Am. Cong. Phys. and Surg.," 1903). Sloughs and gangrenous tissue should be removed and drainage provided. In spite of all care and thoroughness in operating, the disease continues to prove most fatal.

Subacute Pancreatitis.—The operative treatment of subacute pancreatitis is practically the same as that of pancreatic cysts and requires no special discussion. Mayo drained, with success, one case of this nature through the gall-bladder, as is done in chronic pancreatitis.

Chronic pancreatitis is treated by cholecystostomy or cholecystenterostomy.

Robson ("Surg., Gyn., Obst.," Jan., 1908) finds that of one hundred and two operations in patients in whom chronic pancreatic trouble was the chief disease, or where it formed a serious complication of other diseases, 96.1 per cent. of cases were followed by complete recovery, giving a mortality of 3.9 per cent.; but since these statistics were compiled in 1904 experience has very largely increased and the mortality has diminished to a little over 2 per cent. Of course where biliary or pancreatic stones are present such must be removed.

Ruth ("Colorado Medicine," Oct., 1907) removed a mass of calculi which weighed 280 grains and lay throughout the whole length of the gland. He found the duct walls $\frac{1}{8}$ inch thick and very strong.

Pancreatic Lithiasis.—Stones are formed in the pancreatic as in the biliary duct. Calculi existing near the ampulla of Vater may be extracted through a duodenal incision, as in the case of gall-stones. As a rule, the removal of pancreatic calculi has been accomplished incidentally during the evacuation of abscesses in subacute pancreatitis. Moynihan was the first to remove a calculus where the diagnosis had been made prior to operation. When a calculus can be felt in the exposed pancreas it is proper to incise the gland, remove the stone, close the pancreatic wound with sutures, and provide for drainage.

Traumata.—Whenever structures around the pancreas are injured one ought to suspect and look for injury to that organ. When in a case of bullet wound the posterior wall of the stomach is penetrated, it is extremely probable that the pancreas is also involved. Remember, experience teaches that a comparatively slight injury to the gland may lead to disastrous results from leakage of the digestive juice. Lacerated fragments of the pancreas must be removed. Wounds in its substance must be sutured with catgut, care being taken not to occlude the duct by the suture. Whether sutures are used or not drainage must be established, preferably by means of cigarette drains, which may be introduced through the abdominal wound or through a

ecial lumbar wound or by both routes. After the pancreatic lesion has been tended to, it is good practice thoroughly to douche the general peritoneal vity with hot salt solution in order to get rid of, or at least dilute, any effused ncreatic juice.

As anti-diabetic diet diminishes pancreatic secretion (Wohlgemuth), such diet may be of very great value as an adjuvant to the local treatment of juries to the pancreas.

CHAPTER XLI

THE SPLEEN

Surgical Anatomy.—"The spleen is a soft, highly vascular, and easily dis-nsible organ, of a dark, purplish-gray color. It is placed obliquely in the ck of the left hypochondrium, between the cardiac end of the stomach and the aphragm, and in the line of the axilla extends from the eighth to the eleventh ." Its shape is that of a compressed oval having three surfaces. "Of these, e, the external and posterior, is large and convex, fitting against the com-encement of the arch of the diaphragm and looking upwards, backwards, d to the left. A second, the narrowest, is placed vertically, and looks directly wards, being applied to the outer border of the left kidney; whilst the third rface, which is separated from the last described by a distinct vertical ridge, is rger than it and concave. This surface is applied to the great cul-de-sac the stomach and is in contact also with the tail of the pancreas and with the tremity of the arch of the colon (splenic flexure). Near the ridge above entioned there is a vertical fissure in the anterior surface, at the part where e vessels and nerves enter the organ; this part is termed the hilus" (Quain). he spleen is held in place by means of reduplications of peritoneum. Such e the gastro-splenic, pancreatico-splenic, and phreno-splenic ligaments. Occa-onally there is a colo-reno-splenic ligament at the lower extremity of the leen (Villar). The splenic blood vessels are contained in the gastro-splenic nentum. The splenic artery, after giving off the gastro-epiploica sinistra, eaks up into a number of branches, a few of which—the vasa brevia—turn ck to the stomach. The remaining branches enter the spleen at the hilus. he splenic vein, in its origin, corresponds to the artery. It is a large vessel and s below the artery. In its subsequent course it is situated behind the pancreas.

Splenopexy.—Splenopexy is performed for the cure of "floating spleen." veral methods have been devised to anchor the spleen in the left hypochon-ium.

(A) *Rydygier's Method.*—Freely open the belly in the middle line. Locate e spleen. Between the ninth and tenth ribs make a transverse incision rough the parietal peritoneum (Fig. 681). Introduce the fingers through is incision and separate the peritoneum, below the incision, from the parietes, d thus form a pocket whose mouth is directed upwards (A, A, Fig. 682). The uch is made sufficiently large to receive the lower end of the spleen. If the een (B) is placed in this pouch, its weight may enlarge it so that the opera-n is rendered useless. To prevent this, insert a few catgut sutures through

the peritoneum and part of the parietes immediately below the lower limit of the pouch. These will prevent further separation of the peritoneal flap from the parietes. Place the lower end of the spleen in the pouch. Unite the free edge of the peritoneal flap, forming the pouch, to the gastro-splenic ligament by one or more sutures. If it seems desirable, suture the spleen itself to the peritoneal incision, or form, from the peritoneum above, a flap with its base next the spleen; reflect this flap over the spleen and suture it to the gastro-splenic ligament.

(B) *Bardenheuer's Method.*—Place the patient on his right side. Make an incision in the axillary line, from the tenth rib to the iliac crest. At the level of the tenth rib make an incision at right angles to the first. Divide the soft parts down to the peritoneum. Make an opening through the peritoneum of size sufficient to permit of exploration and of the passage of the spleen through it.

FIG. 681.

FIG. 682.

FIGS. 681 AND 682.—Rydygier's splenopexy. (*Monod and Vanverts.*)

Have an assistant, with his hand on the belly-wall, push the spleen towards the wound. Bring the spleen out through the peritoneal wound. With sutures diminish the size of the peritoneal wound and unite it to the splenic pedicle. Pass one stout suture through the lower end of the spleen and tie it around the tenth rib. Close the wound in the soft parts. The spleen now lies with its inferior pole in a retro-peritoneal pouch; its pedicle is fixed to the peritoneal wound, and its body is suspended from the tenth rib.

The foregoing operations are so recent that their merits have not been fully tested; probably Bardenheuer's is the safer and easier.

Splenectomy.—The spleen may be removed for the following conditions (Greig Smith):

1. Injury or prolapse.
2. Certain cases of movable spleen.
3. Simple hypertrophy, with or without cirrhosis.
4. Sarcoma or lympho-sarcoma in the early stages.
5. Cysts.
6. Hydatid disease.

To these indications it is safe to add that of splenic anemia or Banti's disease or hemolytic jaundice with splenomegaly. The results of splenectomy in this condition has been most gratifying and surprising. Tansini in 1901 combined splenectomy with omentopexy in a case of Banti's disease with ascites. The result was excellent. The combined operations have been performed a number of times and while the mortality is high the prospects of complete relief entirely justify the risk (Tansini and Morone, Rev. de Chir., Aug., 1913, Lesio, La Pr. Med., July 31, 1919). Encouraged by the results obtained in Banti's disease Eppinger and Exner performed splenectomy for pernicious anemia on March 15, 1913; Decastello and Finsberger did the same, independently, on March 20, 1913. Lenormant (La Pr. Med., 23, May, 1914) analyzes 24 collected cases with 5 deaths. (Two deaths were *perhaps* not due to the operation.) In the patients who survived there was rapid and constant improvement in the general condition, the appetite improved and weight increased even before there was any improvement in the blood picture. Icterus disappeared and there was diminution in the excretion of urobilin. The blood picture following operation was rather irregular—in some cases it became excellent, in others improvement was not so marked. Ranzi speaks of the dangers which may be present in operation due to adhesions to the diaphragm and to a development and dilatation of vessels almost equivalent to aneurysm.

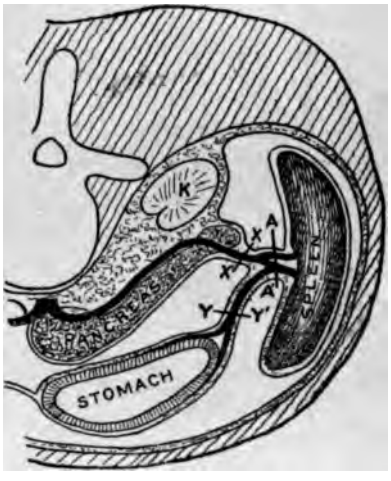


FIG. 683.

In one case reported by Huber the patient showed hemoglobin 10 to 20 per cent.; red cells, 1,000,000; œdema; retinal hemorrhages; slight icterus; urobilinuria; dyspnœa, etc. The patient being too weak for operation was given intra-muscular injections of defibrinated blood and later splenectomy was performed. In five weeks after operation the hemoglobin was 70 per cent. and red cells 2½ millions. In three months the patient could walk.

Eppinger and Ranzi operated on a moribund patient with only 500,000 red cells who recovered to such an extent as to be able to do moderate work.

Balfour advocates transfusion of blood not only as a therapeutic measure but for prognosis. If improvement results splenectomy will probably be of value; if transfusion proves without value splenectomy will fail.

C. H. Peck and others (Trans. Surg. Sect., A. M. A., 1916) advocate splenectomy in hemolytic jaundice.

In cases of leucocythæmia the spleen ought *never* to be removed.

Splenectomy.—Place the patient in an exaggerated Mayo-Robson position, i. e., in marked lordosis.

Step 1. *Method A.*—Make a left rectus incision almost identical with Robson's incision for exposure of the gall-bladder but on the opposite side.

Method B.—Make an incision parallel to and a little below the costal border

he epigastrium to a point opposite the end of the elev
the incision may be continued vertically downwards for a short distan
essary.

ep 2.—Explore the region of the spleen. If adhesions are present never
ure them blindly; usually it is easy to expose, doubly ligate and divide those
he omentum, the colon and the abdominal wall. Adhesions to the dia-
agm are more difficult to master—if it is impossible to doubly ligate them
ore division. Hartmann advises that the operation be given up otherwise
aster is invited.

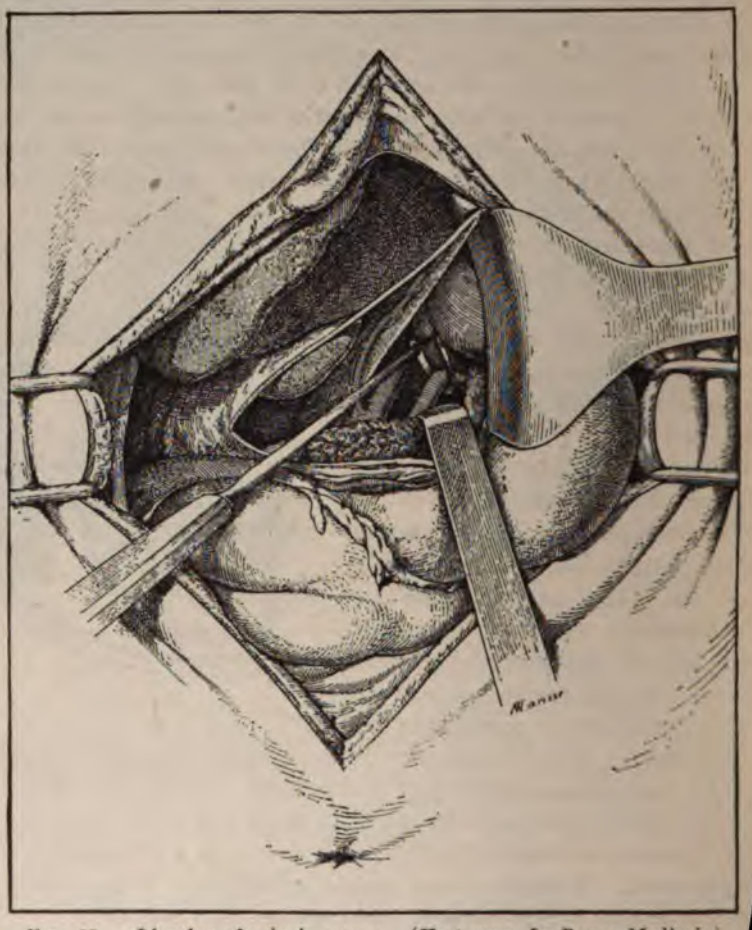


FIG. 684.—Ligation of splenic artery. (*Hartmann, La Presse Medicale.*)

Step 3.—The spleen is now free except for its true pedicle. Deliver fr
abdomen first its inferior pole, then its superior. If the spleen is mobil
its pedicle by transfixion (A A′, Fig. 683) being careful to cross the
Apply a clamp to the pedicle near the spleen. Divide the pedicle bet
ligatures and the clamps. Remove the spleen. Inspect the ligated st
apply ligatures to the individual vessels as an additional safeguard
spleen is *not* mobile, ligation of the pedicle *en masse* is impossible with

ing the tail of the pancreas at the same time. If time is of great importance this may be done though it is generally better to proceed as follows: Pull and rotate the spleen towards the left so as to expose the gastro-splenic omentum with the *vasa brevia* and the left gastro-epiploic vessels running in it from the splenic artery to the stomach. Doubly ligate the *vasa brevia* and the left gastro-epiploics (Y Y′, Fig. 683) and divide the gastro-splenic omentum between the ligatures thus gaining access to the lesser peritoneal cavity. Note the pancreas with the splenic artery and vein on it lying behind the posterior peritoneal wall of the lesser cavity. Pick up and incise the peritoneum over the splenic vessels and tie them (X X′, Fig. 683). Remove the spleen. The splenic vessels may

FIG. 685.—Control of splenic vessels. (*Mayo.*)

e reached not only through the gastro-splenic omentum but through the gastro-epatic, or the gastro-colic omenta or even from below upwards through the ransverse meso-colon. When separation of the spleen is rendered difficult and langerous because of adhesions John Gerster advises ligation of the splenic rtery near its origin. This may be easily accomplished through a hole torn in the lesser omentum (Fig. 684). To this must be added ligation of the left gastro-epiploic artery (branch of the splenic) just as it reaches the stomach, because of its being in continuation with the right gastro-epiploic. The left gastro-epiploic artery may be exposed by pulling the stomach and left margin of the great omentum towards the right. "While cessation of the arterial stream does not afford absolute hemostasis, the hemorrhage from the torn veins alone is

easier of control and is certainly less than if it came from both arteries and veins." (John Gerster, Journ. A. M. A., Aug. 7, 1915.)

Step 4.—With sutures close all the wounds made in the posterior peritoneum and if the gastro-splenic omentum was divided separately suture its stump to the posterior abdominal wall.

Step 5.—Close the abdomen.

In Banti's disease (splenic anæmia) Mayo has found not only complete but even partial splenectomy useful. After exposing and pulling the spleen forwards out of its bed, using blunt dissection to form a passage-way around the pedicle, grasp the pedicle with the blades of a suitable clamp (gastro-enterostomy clamp with blades protected by rubber tubing). Complete the separation of the spleen from its connections and deliver it through the abdominal wound. The forceps on the pedicle should be placed as far away from the spleen as possible for obvious reasons (Fig. 685). If partial splenectomy is chosen, cut away as much of the organ as necessary and close the wound with a continuous button-hole suture of catgut introduced with a round needle; loosen the clamp. If hemorrhage occurs temporarily reapply the clamp and introduce more sutures where they will do most good. If complete splenectomy is chosen the temporary control of the pedicle makes its permanent ligation easy.

Mayo ("Journ. A. M. A.," Jan. 1, 1910) notes that "it has been shown experimentally that reduction of the arterial supply by ligation results in atrophy of the spleen and that as long as the veins are left intact necrosis does not occur. If the splenic artery divides in the hilum, ligation of branches would appear to be an active competitor of partial splenectomy. Lanz (quoted by John Gerster) ligated the splenic artery in the case of a man with a spleen which was adherent in the bony pelvis and which was causing severe pain on urination and defecation. Six months later the splenic tumor could not be palpated. Hartmann (La Pr. Med., 30, Sept., 1911) states that "in the four cases where this ligation has been practised (Battle; Wyman; Tricomi; Küster) the operation was fatal. These failures are explained by the fact that the splenic is a terminal artery without anastomosis. The operation might be done by applying the ligature proximal to the short vessels so that a partial circulation might be established in the spleen by means of the union of the vasa brevia with the other gastric vessels."

CHAPTER XLII

THE SUPRARENAL BODIES

The suprarenal bodies rest upon the diaphragm opposite the eleventh and twelfth ribs. They are separated from one another by an interval of 2 to 2½ inches. They are situated at the upper and inner border of each kidney, and obtain a rich supply of blood through special arteries from the aorta and through branches of the renal and phrenic arteries. In front of the left suprarenal lies the stomach; to its outer side is the spleen. The right suprarenal "is related in front to both the inferior and posterior surfaces of the right lobe of the liver (impressio suprarenalis); internally to the vena cava, which slightly overlaps it,

ıd its inferior angle is crossed by the first bend of the duodenum. It lies :hind the foramen of Winslow." (Woolsey.)

Adrenalectomy.—The surgery of the suprarenal bodies belongs more to the ture than the present but even now enough has been done to demand a short)tice here.

The most common cause of Addison's disease is tuberculosis of the supra-nal body, and most of the successful operations have been performed in such ses. Usually operation has been undertaken on a diagnosis of "retro-perito-al tumor" or of a tumor affecting the upper pole of the kidney, and these rors in diagnosis are liable to be repeated in the future. An early recogni-on of suprarenal disease is impossible in our present state of knowledge or norance.

The suprarenal bodies may be reached through the lumbar region or through ıe peritoneum. When the former route is chosen, the incision must be ex-ınsive, and exactly like that for nephrectomy. In most cases of adrenalec-)my, nephrectomy will be part of the operation, for two reasons: (*a*) because he removal of the kidney renders less difficult an atrociously difficult operation; *b*) because the kidney is often involved in the disease, especially if that disease s malignant.

Helferich operated through the lumbar route and partially removed a uberculous suprarenal with complete success (Schede, "Handbuch der prak-ischen Chir.," iii, 1106). Most operations have been performed by the trans-eritoneal route. Oestreich diagnosed and Hadra operated upon a pulsating umor of the suprarenal. When the abdomen was opened in the middle line bove the umbilicus, a tumor the size of a hen's egg, of a whitish and yellowish-rown color, was seen through the lesser omentum. This tumor was on and) the left of the aorta, and after excision proved to be a much caseated supra-nal body. The wound was packed and the patient recovered. In a case erated on by Jonas (Schede, *loc. cit.*) the bronze hue so characteristic of ldison's disease faded in ten days and disappeared in three weeks. There little prospect of much benefit from operation on malignant tumors of the prarenals.

CHAPTER XLIII

OPERATIONS UPON THE LIVER

ERATIONS FOR HEPATOPTOSIS, OR MOBILE OR FLOATING LIVER

Ptosis of the liver may be partial or complete.

Partial ptosis means that a portion of the liver in more or less pushed away snared off from the rest of the organ as a result of error in dress (tight lacing) of some disease. Riedel's tongue-shaped lobe, so common in cholelithiasis, y be a form of partial p... Occasionally the junction between the aberrant e and the rest of ... thin, and from irritation, etc., has become rosed.

Complete ptosis means that the liver is dislocated *en masse* to a greater or less degree.

(A) **Operations for Partial Hepatoptosis.**—1. *Indirect Operations.*—When the ptosis is in the form of a Riedel lobe and dependent on gall-bladder disease, the latter disease must be treated according to the methods advised in the chapter on Biliary Surgery. Excellent results are thus obtained.

2. *Excision.*—The mobile lobe may be excised. (See "Hepatectomy.")

3. *Ventro-fixation.*—Open the abdomen over the most prominent part of the tumor. Suture the "floating lobe" to the parietes by several thick catgut sutures. Before tying the sutures scarify the surfaces about to be opposed.

4. *Kehr's Operation.*—Kehr, adopting Rydygier's idea in splenopexy, applies it to the fixation of partial hepatoptosis. Make a horseshoe-shaped incision (concavity upwards) around the lower circumference of the mobile lobe down to but *not* through the transversalis fascia. At the lowest point in the wound open the belly by a transverse incision through the transversalis fascia and the peritoneum. Separate the transversalis fascia and the peritoneum, together, from the more superficial structures of the parietes over an area corresponding to the horseshoe-shaped incision. At the upper end of this loosened area make an incision through the fascia and peritoneum parallel to the lower transverse incision. A pocket of fascia and peritoneum is thus formed into which the "floating lobe" or its lower margin may be tucked and secured. Close the wound with sutures.

(B) **Operations for Complete Hepatoptosis.**—(I) *Step* 1.—*Exposure of organ:* This may be accomplished by a vertical incision either in the middle line or along the external border of the right rectus muscle or by a cut parallel to the costal arch. The vertical incisions are the better, and may be supplemented by a transverse cut *if* such appears necessary.

Step 2.—*Return the liver to its normal position:* If the organ has become adherent in its faulty location, and adhesions must be separated, unless, of course, they are so extensive that the danger involved in their separation would be out of proportion to the good to be attained by a successful hepatopexy. An assistant supports the liver in its improved position while the surgeon carries out the next step.

Step 3.—*Fixation of the liver by sutures:* Pass coarse catgut or silk sutures through the parenchyma of the anterior edge of the liver, each suture taking a deep hold of the organ, and then make the sutures penetrate between the cartilages of the adjacent ribs. During this procedure the pleura has been injured, but no harm has resulted. The sutures must be thick to avoid cutting the friable organ. In actual practice the number of sutures has varied from two to eight; the more numerous they are, the more is the strain divided and the liability to cut lessened. The hepatic and parietal surfaces which are to be opposed should be scarified before the sutures are tied. Care must be taken, when the sutures are being tied, to avoid cutting the liver substances with the threads. Some surgeons apply a few sutures between the liver and the upper end of the abdominal wound. Lucas Championnière modifies the operation by passing some of the threads through the suspensory ligament.

If it is impossible to reduce the liver, it may be fixed by suture wherever sible so as to give relief from distressing symptoms.

(II) *Depage's Operation* (*Hepatopexy and Laparectomy*).—Depage considers ity of the abdominal walls a great factor in the production of hepatoptosis l directs his attention specially towards removal of this condition.

Step 1.—Make the horizontal incision A B (Fig. 686) from the tip of the enth rib on one side to the tip of the eleventh rib on the other side. From point A make an incision A C, downwards and inwards to meet an imaginary passing horizontally through the umbilicus. The length of the cut A C qual to one-half the cut A B. From the point B make the incision B D in same way as A C was made. From the point C and D make curved in- ons downwards to near the pubis. The convexity of the curves is outwards.

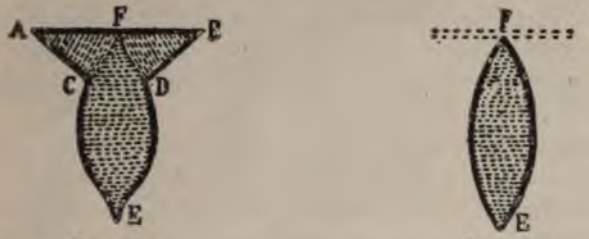


FIG. 686. FIG. 687.

FIGS. 686 AND 687.—Depage's laparectomy. (*Monod and Vanverts.*)

se cuts meet at the point E. Remove all the skin enclosed by the above sions. Dilatation of the belly has caused the linea alba to become very e. "Remove the linea alba, including the peritoneum, from the anterior nternal border of one rectus muscle to the internal borders of the other us muscle. Make traction upon the umbilical ligament of the liver and inferior extremity of the falciform ligament, and, pulling them into the er angle of the wound, shorten and anchor them there by sutures."

Step 2.—Suture the abdominal wound with extreme care. Depage sutures lanes as follows: (*a*) The peritoneum alone; (*b*) the peritoneum and mus- r planes together; (*c*) the muscular plane alone; (*d*) the aponeurotic and cular planes together; (*e*) the aponeurosis alone; (*f*) the skin and sub- aneous tissue together; (*g*) the skin alone. In suturing, the edge of the nd A C is united to the edge A F; the edge B D to B F, and the edge C E to edge D E. The resultant scar is **T**-shaped (Fig. 687).

HEPATECTOMY. EXCISION OF HEPATIC TUMORS, ETC.

As it is self-evident that the liver can never be removed *in toto*, it is useless refix the word partial to the title of this section.

The experiments of Ponfick, repeated and supported by other observers, e proved that much liver tissue can be removed without specific injury ee-fourths was removed in animals), and that new liver tissue is formed to the place of that removed. The great impediment to hepatic surgery been the fear of hemorrhage. Many methods have been adopted to over- e this real danger. A few of the methods will be described.

I. **Exposure of the Tumor.**—The abdomen is opened over the tumo
[illegible] made in any direction which may be convenient or by a combina
[illegible]. The incision must be large enough to give very free access to th
[illegible] of operation. The tumor is now examined as to kind and location. I
[illegible] that the diagnosis is such that radical operation is permissil
the tumor involves most of the right lobe of the liver, the operation n
[illegible] abandoned at last if the bilus is much involved. Tumors on t
[illegible] and superior parts of the liver are inaccessible. Tumors of t
[illegible] and of the anterior margin of the organ may be brought forwa
[illegible] of parts of the hepatic ligaments: this permits of partial disl
[illegible] the whole organ. Some surgeons have excised the lower ribs (sul
[illegible] and have thus been enabled to retract the diaphragm upwards.
the patient is lying on his back with the posterior hepatic region support
[illegible] it is extraordinary how much of the liver may be brought out t
the Mayo-Robson incision page 505 without any resection of ribs.
[illegible] to believe that enough benefit can be attained by rib resection to v
the extra trauma and risk.

II. **Removal of the Tumor.**—When peritoneum exists over the tun
is free from disease. It should be divided and reflected from the surfac
tumor. If the tumor is non-malignant and appears to be fairly well
[illegible] it may often be shelled out of its hepatic bed with but little hemc
When the tumor is very small and situated at the liver margin, it may
moved by a V-shaped incision made with knife, scissors, or thermoc
While the cut is being made an assistant compressing the neighborir
controls bleeding temporarily. When the tumor is attached to the l
a distinct pedicle, the pedicle may be surrounded by an elastic ligat
the tumor removed, or the removal may be accomplished without the
the elastic constrictor. In all the above instances bleeding is tem
controlled while the tumor is being removed. When the tumor is
capsulated, non-pedunculated, or involves much of the liver substan
requires to proceed step by step, stopping bleeding as one goes.

Methods of Hemostasis.—I. During the operation:

(a) *Temporary elastic ligature:* A rubber tube thrown around a
permits the surgeon to remove the tumor at his leisure and subsec
take other means to stop the bleeding permanently. When there
pedicle it has been advised to pierce the whole thickness of th
behind the tumor with a cannula, place a *double* elastic ligature throu
instrument, and tie the ends of the ligature on each side of the tumor
act as a tourniquet.

(b) **Pringle's Method.**—Pringle ("Annals Surg.," xlviii, p. 541) ha
digital compression of the portal vein at the foramen of Winslow an
secured good, safe temporary hemostasis. To gain access to wounds
liver after temporary hemostasis is secured, Pringle thinks well of Langen
suggestion to divide the coronary and right lateral ligaments so as to all
liver to be dislocated and delivered up to the abdominal wall, or to giv
room [illegible] viding some of the lower ribs and turning up a flap of ri
di[illegible] Willy Meyer has carried out this plan.

McDill's Method.—McDill ("Journ. A. M. A.," Oct. 5., 1912) compresses essels by means of an enterostomy forceps, the blades of which are ted with rubber tubing. After the gall-bladder region is fully exposed usual fashion McDill makes a 1-inch skin incision immediately below ostal margin in the right axillary line, tunnels from here through the es and introduces the enterostomy clamp through the tunnel (Fig. 688).

Auvray recommends applying to the liver around the portion to be ed a series of interlocked ligatures of thick silk or catgut. To apply gatures use a blunt pedicle needle with a very long curve. Each indi- ligature, after being crossed with its fellow to the right and left, is slowly

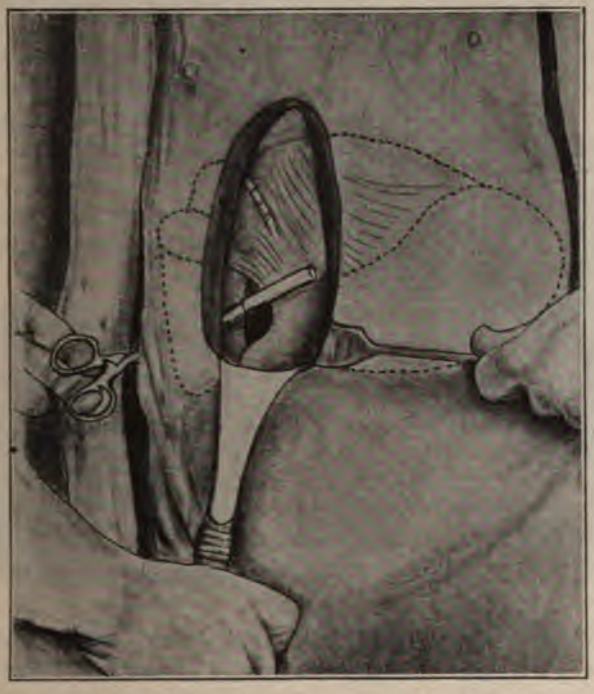


FIG. 688.—(*McDill, Journ. A. M. A.*)

steadily tied with such firmness that the liver parenchyma is cut, but essels remain undivided in the loop. When the whole series of ligatures d, the tumor is removed with cautery, knife, or scissors. It is of impor- while transfixing the liver with the needle to use little force, and when bstacle to the passage of the instrument is encountered, to manipulate edle from side to side and so gently guide it past the obstruction. Such uctions are usually large vessels, and any force used might injure them. points of transfixion should be about one centimeter (⅜ inch) apart. y's researches have been very thorough and successful. The method vises certainly appeals to one's common sense.

ing practically the same method as Auvray, Cullen has removed a large oma of the liver. He used silver needles straight and curved, exactly the

same as Hagedorn's except that they had blunt ends. After the ligatures were in place he found that the "raw surface could be rolled in upon itself, so that the two halves formed flaps. These were brought together until little or no raw surface remained. The ends of the sutures that had already been tied were utilized to bring the opposite sides together."

Freeman has used with success, for the same purpose and in similar manner narrow strips of gauze. He found much difficulty in removing the gauze because the knots sank into the liver substance, so he now recommends that the ends of gauze be fastened with forceps or catgut instead of being knotted. ("Trans. Am. Surg. Assoc.," 1904.)

Kornew and Schaack (Zent. für. Chir., M, June, 1913, page 949) have frequently successfully removed large masses of liver in dogs as follows: Take two broad strips of fascia (obtained from any convenient place on the same patient, *e.g.*, the thigh) and place them on the upper and under surface of the liver just internal to the line of proposed section. With a long rounded needle introduce near the

FIG. 689.

FIG. 690.

FIGS. 689 AND 690.—(*Kornew and Schaack, Zentralblatt für Chirurgie.*)

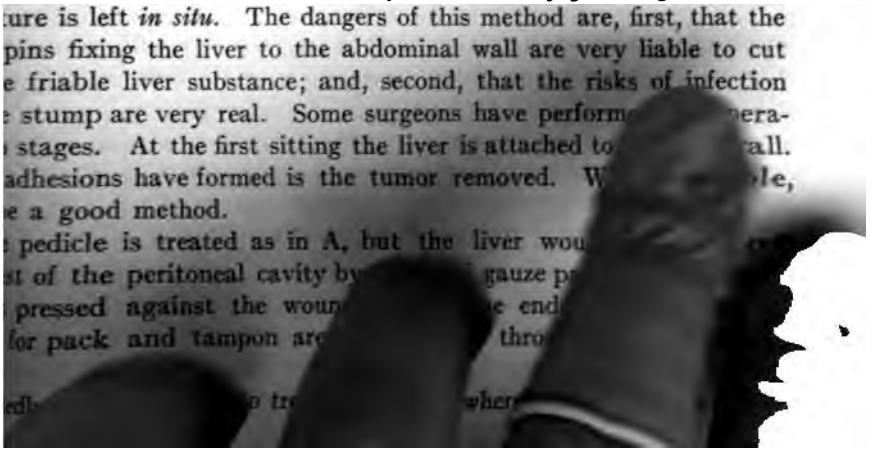
inner edge of the strips of fascia a row of continuous mattress sutures. These sutures are of thick catgut or silk and pass through both the fascial strips and the liver and ought to be applied in the shoemaker fashion. After the sutures are pulled tight they are tied together at the anterior and posterior edge of the liver (Fig. 689). Cut away the portion of liver condemned Cover the liver stump with the cuff formed by the fascia (Fig. 690).

Auschütz ("Deutschen Gessellsch. für Chir.," 1907) lays down the following rules for resection of the liver:

1. The incision through the liver substance should be made with a sharp knife and the vessels picked up with forceps and ligated. If the hepatic tissue is divided by blunt force the vessels subsequently retract and are difficult to find and secure.

2. When possible the liver wound should be wedge-shaped to permit closure with suture.

special instruments are required for the insertion of deep ligatures
r. The ligatures should be tied slowly but firmly.
uitable cases the temporary use of an elastic ligature is valuable.
ally no abdominal tampon is required after suture.
ision of the hepatic ligaments is often an aid in resection.
en it is necessary to attack the dome of the liver, do not hesitate to
right costal arch and to divide the suspensory ligament.
uses catgut No. 2 for deep sutures which go through the whole thick-
e liver, while for serous sutures and for the ligation of individual
the cut surface of the liver he uses extremely fine silk. He does not
tump extraperitoneally, has not lost a single case and has penetrated
ibstance to the extent of fully 5 inches (10 to 14 cm.).
ermocautery: Many surgeons use the thermocautery instead of the
1 dividing liver. While the cautery does not control bleeding from
vessels, it certainly does control oozing. The cautery ought always
ly when hepatic incisions are made, since it may be found useful,
an aid to other methods.
ature: The ligation of hepatic vessels is often difficult, their walls
and delicate. Frequently direct ligation of the vessels is impossible.
is the case, one may, with a curved needle, pass a suture around
and on gently tying it the bleeding ceases. To this suture-ligature
ns give the name "Umstechung."
ove are the principal means of hemostasis used during the operation.
e methods of securing hemostasis after the operation are practically
s the methods of treating the stump.
traperitoneal.—The liver wound, having been closed by suture or
: charred by the thermocautery, is allowed to drop back in the belly.
al flaps were dissected back from over the tumor, they are replaced
:d together. Place a strip of gauze under the liver and against
ound; bring the end of this strip out through the abdominal wound.
xcess of wound.
traperitoneal.—The tumor is delivered through the abdominal wall.
e is compressed by an elastic ligature. The tumor is cut away.
is fixed to the abdominal wall by sutures or by pedicle pins. The
ure is left *in situ*. The dangers of this method are, first, that the
pins fixing the liver to the abdominal wall are very liable to cut
e friable liver substance; and, second, that the risks of infection
stump are very real. Some surgeons have perform[illegible]era-
stages. At the first sitting the liver is attached to [illegible]all.
adhesions have formed is the tumor removed. W[illegible]le,
e a good method.
pedicle is treated as in A, but the liver wou[illegible]
st of the peritoneal cavity by [illegible] gauze p[illegible]
pressed against the woun[illegible]e end[illegible]
for pack and tampon are[illegible] thro[illegible]
edl[illegible] to tr[illegible] wher[illegible]



bination of suture and packing. The surface of the pack facing the abdominal cavity should be covered by rubber tissue. The ends of the catgut sutures applied to the liver should be left long and tied over the pack so as to keep the latter in place. (See "Cholecystectomy.")

To exert hemostatic pressure upon the liver and to prevent the cutting of the parenchyma by sutures one rubber tube may be laid on the upper surface of the liver, another on the lower surface. Thick catgut sutures (A, B, Fig. 691) penetrating the liver are fastened to the tubes. The ends of the tubes are brought out of the wound and are to be removed when they have served their purpose. Instead of rubber tubes, plates of decalcified bone and of various materials have been employed.

FIG. 691.—Hemostasis liver.

Kocher has applied his large stomach clamp to the liver with force, crushing through the parenchyma and excising the portion of liver distal to the clamp. He leaves the clamp *in situ* for forty-eight hours.

Van Buren Knott has successfully removed a primary sarcoma from the anterior border of the liver (the tumor was pedunculated and weighed over one pound) using rubber-covered clamps which he left *in situ*. The operation was difficult because of adhesions and the patient was much debilitated.

Stuckey ("Archiv. für klin. Chir.," xcix, 384) in cases of hemorrhage from the liver after cystectomy has found that he could stop the bleeding as follows: Pick up a terminal segment of omentum of suitable size, ligate and excise it. Cover the liver wound with the excised (free) flap of omentum and hold it in position by gauze pressure for a short time. Very quickly the omentum adheres to the liver wound and stops the bleeding. A gauze pack may be used to hold the graft in position as an extra precaution.

ABSCESS OF THE LIVER

Aspiration.—Aspiration as a method of treatment for liver abscess is not to be recommended. It has its sphere of usefulness as a means of diagnosis, but its use is not without danger.

The skin is cleaned over the most prominent or most tender part of the swelling, usually the ninth or tenth interspace vertically below the angle of the scapula, and the sterilized aspirating needle is inserted in various directions until pus is found. Greig Smith remarks that "the movements of the needle, following the movements of the liver (if it moves with respiration), must not be checked, as thereby the liver tissue may be torn and permit escape of pus into the peritoneum."

Hepatotomy.—(A) *Abdominal Route.*—The object of operation is to expose the enlarged liver; to examine it; to incise and evacuate the contained pus without soiling the general peritoneal cavity. An incision four to five inches in length is made over the most prominent part of the swelling. This incision is usually longitudinal. The belly is opened and the liver examined. If the liver is found adherent to the parietes opposite the wound these adhesions

ght to be preserved, as the avoidance of peritoneal contamination is ren-
ed easier by their presence. When a sufficiency of adhesions is not pres-
, the portion of liver about to be attacked is carefully isolated from the
itoneum by pads of gauze. Unless the exact location of the abscess is
y evident, an aspirating needle is passed into the liver until pus is found.
e needle being held in place, a knife or the blade of a cautery is inserted
o the abscess, guided by being kept in contact with the needle. The needle
withdrawn. The forefinger is pushed into the abscess along the side of the
ife, which is now taken out. The abscess cavity is explored digitally and
y signs of a second abscess noted. If such exists, it may be opened from
e first cavity by the finger or a closed hemostat being pushed into it. The
scess cavity is now carefully douched with hot water, a rubber drainage-
be is inserted to its deepest part, and the rest of the cavity loosely filled with
ldly iodoformized gauze. The pads of gauze which have protected the
itoneal cavity are removed and the neighboring peritoneum is mopped
an and dry. Smith recommends that the whole length of the incision in
e liver be sutured to the abdominal wound. This may be done with very
arse catgut or silk sutures. Coarse sutures are necessary, as fine ones would
t through the liver substance. Any of the abdominal wound unoccupied
attached liver is closed by sutures. Abundant absorbent dressings are
plied and the patient put to bed.

According to the amount of discharge the wound will require dressing at
ore or less frequent intervals. The outer dressings, *i.e.*, those down to the
ainage-tube, will probably require to be changed in a few hours. Unless
manded by the condition of the patient, the packing of iodoform gauze filling
e abscess cavity ought not to be changed before twenty-four or forty-eight
urs after operation. When the packing is withdrawn, if necessary, the
scess cavity may be gently douched with hot water. This is best accom-
shed by attaching a soft-rubber catheter to the tube of an irrigator and pass-
it into the deepest part of the cavity. Thorough and gentle lavage is thus
ured. The irrigator ought not to be elevated much more than two feet.
ter washing, the cavity is once more loosely filled with mildly iodoformized
uze and the dressings applied. In all such cases iodoform is better than
in gauze, but the iodoform ought to be in small quantity, as absorption is
ble to be great in such an organ as the liver.

(B) *Transpleural or Thoracic Route.*—When the abscess is situated far
ck on the dorsum of the liver, evacuation by the abdominal route is inap-
cable. By the time that a hepatic abscess has become large enough to be
gnosed and its position ascertained, there is almost always adhesive pleuritis
sent; the liver is adherent to the diaphragm, and the diaphragmatic pleura
the parietal, so that a safe route exists to the pus via the obliterated portion
he pleural cavity.

The Operation.—Place the patient on his sound side. Demonstrate the
sence and location of the pus by the aspirating needle introduced through
ninth or tenth intercostal space vertically below the angle of the scapula.
ke an incision about three or four inches in length along the rib immediately
ow the aspirating needle. Excise about two inches of this rib, subperi-

osteally. As a rule, the site of the excised rib is below the pleura or this portion of pleura is obliterated. If the pleural cavity is opened by accident or design, it must be at once protected (*a*) by the insertion of a few catgut stitches to close the cavity, (*b*) by applying a pack of gauze. This gauze pack may well be held in place by a few stitches of fine plain catgut. By the time it is safe to remove the gauze the catgut will have been absorbed. The diaphragm lies exposed; seize it with forceps and incise it. This exposes the liver, usually adherent to the diaphragm. The aspirating needle still *in situ* forms a guide to the abscess, which must be evacuated as described in the preceding paragraphs.

Choice of Operation.—Many surgeons consider the thoracic route the preferable. When sufficient adhesions are present, it undoubtedly is exceedingly safe, but, on the whole, the abdominal route is the better. More cases of liver abscess can be reached through the abdomen than through the chest, and, while a satisfactory examination of the liver for secondary and complicating disease is possible, the dreaded increased danger from possible soiling of the peritoneum can be practically completely averted by suitable packing with gauze.

SUBPHRENIC ABSCESS

Subphrenic abscess is commonly a sequel of perforative gastric ulcer, of appendicitis, and of hepatic abscess; its treatment may be merely an extension of the treatment of the primary disease. The treatment, of course, consists in evacuating the pus and in securing efficient drainage. The pus is reached in practically the same manner as is that in a hepatic abscess, and the methods require no special description. Counter-openings for drainage may be necessary.

CHAPTER XLIV

OPERATIONS ON THE BILIARY PASSAGES

Operations on the gall-bladder and bile-ducts are most commonly required because of the presence of gall-stones or of infective processes.

Preparation of the Patient.—The preparation for the operation is identical with that for almost any other abdominal operation, but when chronic jaundice is present, calcium chloride should be administered by the mouth in thirty-grain (gr. xxx) doses for two or three days prior to the operation, and in sixty-grain (gr. lx) doses per rectum for a few days thereafter (Mayo-Robson). This rather heroic exhibition of calcium chloride is the great preventive of the hemorrhage which is so often fatal after operations on the jaundiced. All cases of obstruction due to stone in the common duct, in which purpuric spots are present in the skin, die from hemorrhage if operated upon. Some of these cases when treated with calcium chloride improve sufficiently for operation to become justifiable.

Position of the Patient.—Place the patient on his back and support the region of the liver on a firm sand-bag 18 inches long, 6 inches wide, and 3½ inches deep. This opens the costal angle and makes the intestines gravitate

ı the field of operation; it also pushes "The spine forwards, and with it the · and bile-ducts, so that the common and hepatic ducts are brought several es nearer to the surface." (Robson.) this position (Robson's) is con- ently obtained without the use of a sand-bag on the table shown in Fig. 692. met Rixford uses exactly the opposite posture, the chest and thigh being ı raised so as to relax the abdomen.

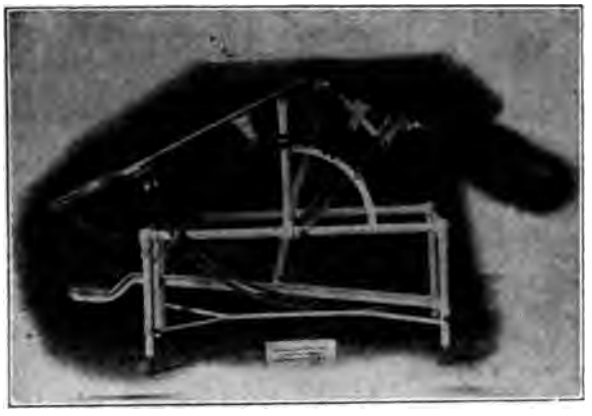


FIG. 692.

Method of Exposure of the Gall-bladder and Ducts.—Very many in- isions have been advocated and used.

Method A.—McArthur's incision: Make a vertical incision through the ectus over the gall-bladder. Retract the edges of the muscle wound. Note he aponeurosis of the transversalis muscle with some of its muscle fibres unning transversely in the posterior rectus sheath. Divide the posterior rec- us sheath transversely to the long axis of the body. his wound is easily and securely closed and gives ufficient access in easy cases of cholecystostomy. If ore room is required the wound may be converted nto a Bevan incision.

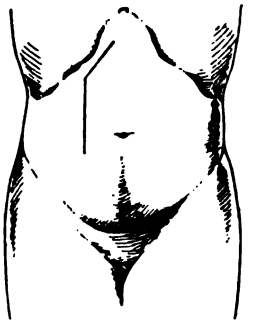


FIG. 693.—Mayo-Robson's incision.

Method B.—Mayo-Robson's incision: Make a ertical incision over the middle of the right rectus uscle. Separate the fibres of the muscle with the ngers or the handle of a scalpel. Divide the posterior heath of the rectus and the peritoneum together. his incision is two to three inches in length. When it necessary to explore the hepatic, common, or deeper ortion of the cystic ducts, continue the original ision *upwards* as far as possible in the space between the ensiform carti- and the right costal margin following the costal margin (Fig. 693). incision is similar to the upper part of Bevan's incision. It freely the upper surface of the liver. Lift the lower border of the (if necessary, drawing the organ downwards from under), thus bringing the whole of the gall-bladder and the

cystic and common ducts quite close to the surface. As the gall-bl is usually strong enough, let the assistant take hold of it with his finge forceps and by gentle traction keep the parts well exposed, while at the time he protects and retracts, with a sponge in his left hand, the left si the wound and the viscera, which would otherwise obstruct the view. will now be observed that instead of the gall-bladder and cystic duct ma a considerable angle with the common duct, an almost straight passa found from the fundus of the gall-bladder to the entrance of the bile- into the duodenum, and if adhesions have been thoroughly separated, the

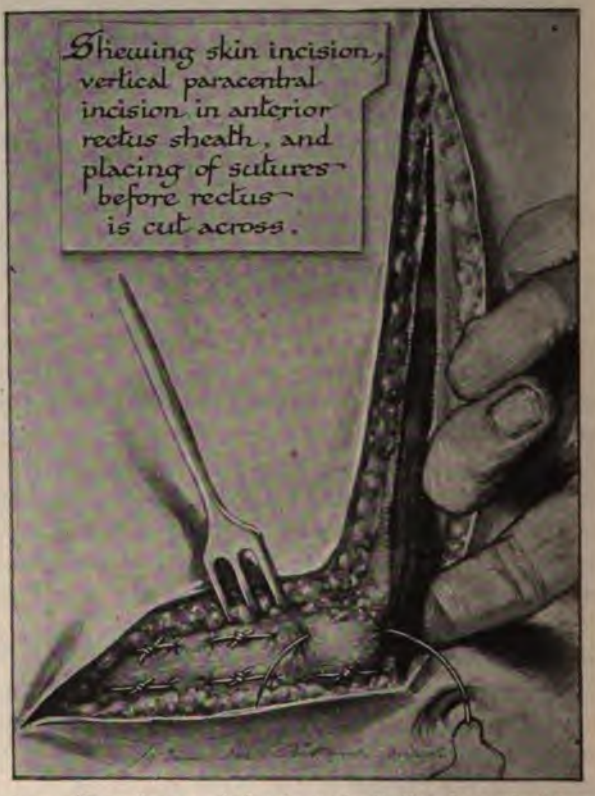

Shewing skin incision, vertical paracentral incision in anterior rectus sheath, and placing of sutures before rectus is cut across.

FIG. 694.—(*Gray*, by permission from the *British Journal of Surgery*.)

geon has immediately under his eye the whole length of the ducts with head of the pancreas and the duodenum. (Robson, "Brit. Med. Jo January 24, 1903.)

Method C.—Bevan's incision: Bevan criticizes the vertical incision in right semilunar line as being insufficient, and when long, objectionable bec of nerve destruction; a **T**-shaped incision is difficult to close and is liable to to hernia; median incision does not give free access to the gall-bladder. advocates the following method ("Annals of Surgery," xxx, 17): Ma vertical incision along the outer border of the right rectus muscle or bet its outer fibres. This suffices for the exploration or the completion of a si

tomy. If it seems necessary to expose or work on the ducts, enlarge cision by continuing its upper end obliquely upwards and inwards, its end obliquely downwards and outwards.

ethod D.—Kehr's incision: From the ensiform process make a cut in the e line downwards for about 1½ inches; then divide the right rectus ob- y and continue the cut downwards in the semilunar line.

ethod E.—Kocher's oblique incision: Make an incision four inches in ı parallel to and about two inches below the right rib margin. This on divides the outer fibres of the rectus muscle and portions of both the

FIG. 695.—(*Gray*, by permission from the *British Journal of Surgery*.)

nal and external oblique. Branches of the intercostal nerves run across ncision towards the rectus, and these must be retracted downwards or rds and preserved uninjured. Kocher's incision gives very free access e biliary region, but necessitates an undue amount of muscle injury.

ocher also uses an incision which passes in the middle line from near the rm cartilage to near the umbilicus and thence outwards through the rectus le. Pannett modifies this cut as follows: "A long paramedian rectus h incision is made from about 1 inch below the ensiform cartilage to the icus, and the abdomen opened in the usual way. Exploration is then to ascertain whether exposure is adequate. If it is not, the anterior

rectus sheath is separated from the muscle and pulled outwards. The rectus itself is divided part of the way across, at a point midway between the ensiform cartilage and the umbilicus. . . . . With adequate retraction such an incision gives ample room. . . . ."

Method F.—Fritz König's incision: F. König thinks that high epigastric incisions affect respiration unfavorably. Beginning not less than three finger-breadths below the ensiform cartilage make a median incision downwards for ¾ to 1½ inches then curve the cut transversely across the right rectus muscle to its external margin. It is always possible to avoid injuring the nerves. The location of the transverse part of the incision depends on how low the liver and gall-bladder lie. Perthes' incision is very similar but has some distinctive features. H. M. W. Gray endorses its value. (Brit. J. of Surg., I, page 200.) Make a vertical incision through the right rectus close to the middle line from the ensiform to the umbilicus. From the lower end of this incision cut horizontally outwards, through the skin and subcutaneous tissues, to near the costal margin. With two rows of sutures unite the aponeurosis to the rectus muscle (Fig. 694). Divide the rectus transversely and reflect it upwards, and outwards as a flap with the skin (Fig. 695). Divide the posterior sheath of the rectus and the peritoneum obliquely near the base of the muscular flap. The vascular and nerve supply of the rectus is well protected.

Method G.—Sprengel's incision: Oblique section of the right rectus parallel to the costal arch. If more room is required make a short incision upwards and outwards at the outer end of the wound and split the fibres of the external oblique. Retract the edges of the wound in the external oblique and separate the fibres of the internal and transversalis. If the common duct requires exposure extend the incision so as to partially or completely divide the left rectus.

Method H.—Rutherford Morison's incision: Make a transverse incision from the ileo-costal space behind to the outer edge of the rectus in front. Besides giving free access to the gall-bladder and ducts this permits of easy posterior drainage.

EXAMINATION OR EXPLORATION OF THE GALL-BLADDER AND BILE-DUCTS

When the abdomen is opened, the gall-bladder is usually easily recognized and it is easy to palpate this viscus, to follow the cystic duct downwards, and, by passing the finger through the foramen of Winslow, to palpate at least the supra-duodenal portion of the common duct. Often the gall-bladder is hidden in a mass of adherent omentum or other viscera, or it may be much shrunken as well. Under these circumstances, beginning at the liver margin, separate the adhesions. Use the liver as a guide to the site of the gall-bladder. Many of the adhesions may be separated by the fingers, but many must be cut between ligatures. The separation of adhesions must be accomplished with much circumspection, as nature occasionally herself performs the operation of cholecystenterostomy, and when this is the case, the surgeon is liable to penetrate the junction between the gall-bladder and the gut. When this accident occurs, the hole in the gut must at once be closed by a double line of sutures.

When the gall-bladder is much shrunken, the search for it makes a severe call on the patience of the surgeon. When the gall-bladder is distended or not shrunken, it is easy to pull it up into the wound. Before breaking down adhesions around the biliary passages be careful to protect thoroughly the peritoneal cavity by means of suitable pads or sponges. When freeing the gall-bladder and the ducts from surrounding adhesions, one is liable at any moment to open into some collection of infective material, and dangers from this source must be guarded against. As was hinted when describing Robson's incision, it is of first-rate importance to free the bile-ducts from surrounding adhesions; if this is not done, the exploration becomes a sham. The guide to the common duct is the gall-bladder and cystic duct.

OPERATIONS ON THE GALL-BLADDER AND DUCTS

Ideal Cholecystotomy.—This operation consists in opening the gall-bladder, removing any stones which it may contain, and closing the wound by two layers of sutures exactly as one would close a wound in the small intestine. Bernays has advocated this procedure and called it ideal. Vautrin carried out a similar operation, but sutured the closed viscus to the upper part of the abdominal incision (cholecystopexy). Union of the gall-bladder to the upper part of the wound has the advantage that, the fundus being fixed in an elevated position, natural drainage of the viscus is aided.

Cholecystostomy.—Cholecystostomy is an operation which creates a fistula between the gall-bladder and the parietes. It may be executed in either one or two sittings, usually in one.

Cholecystostomy in Two Sittings.—First sitting: Expose and explore the gall-bladder and ducts. Bring the fundus of the gall-bladder into the upper part of the abdominal wound and suture it to the peritoneum and deepest layer of fascia (transversalis fascia), but *not* to the skin. It is *said* that the sutures ought not to penetrate into the cavity of the viscus, but should merely include a portion of the thickness of its wall (serous and muscular, not mucous, coats). Close the rest of the abdominal wound with sutures. It is well to attach a long silk suture to the exposed portion of the fundus of the gall-bladder, to act as a guide when the viscus is opened at a later date.

Second sitting: In a few days, when adhesions have formed between the gall-bladder and the abdominal wall, make an opening with a knife into the gall-bladder and so establish the fistula.

This operation is eminently safe and was a great aid in establishing the surgery of this region, but to-day the operation in one sitting has become practically as safe and has the incomparable advantage that it permits the finger on the outside of the gall-bladder to assist in the extraction of calculi and in exploration. When the finger cannot enter the abdominal cavity outside the gall-bladder, the extraction of *all* the calculi present becomes a matter of extreme uncertainty. The "two stage" operation is obsolete.

Cholecystostomy in One Sitting.—Expose and explore the gall-bladder and ducts. Separate all adhesions which impede the work. Thoroughly protect the belly cavity with gauze pads. If the gall-bladder is sufficiently

large, pull it up into the abdominal wound. Seize the fundus with two small volsellae.

If the organ is tensely filled with fluid, it is usually advised to empty it by means of an aspirator. When the contents are thick, and they usually are so, a small aspirating needle is useless, and a large needle puncture, it seems to the writer, possesses no advantages over a cut. The advantage of aspiration is avoidance of soiling the wound.

Make a small incision into the viscus. Mop away all fluid which escapes. Enlarge the opening. Remove with the scoop (Fig. 696) any calculi which may be present in the bladder or adjacent portion of cystic duct. A finger

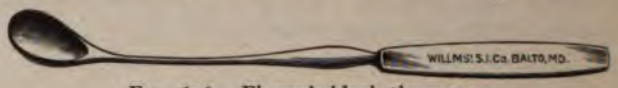


FIG. 696.—Finney's block tin scoop.

outside the gall-bladder greatly aids. Often stones lying in the cystic and rarely the common ducts may be coaxed by the finger (outside the bladder) up into the bladder and so removed. Too much time must not be expended in trying to coax such stones into the bladder, as other and surer means of extracting them are available. Once more explore the interior of the gall-bladder with the finger. When exploring the gall-bladder after it has been opened, much information may be obtained by palpating with a finger of one hand inside the viscus and the fingers of the other hand outside it, but inside the belly. Occasionally one finds the gall-bladder *apparently* divided into two

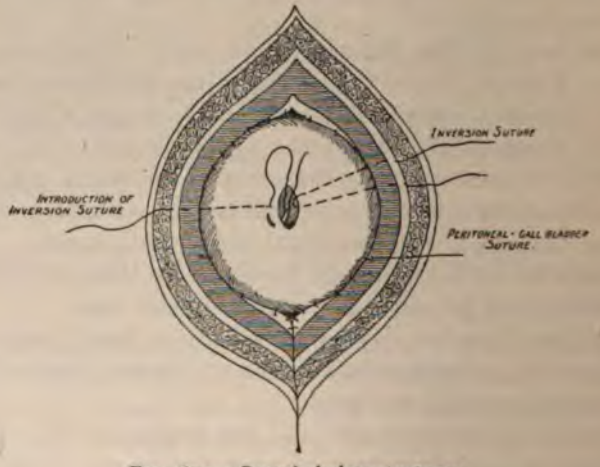


FIG. 697.—Jones' cholecystostomy.

cavities, both containing calculi. The septa between such cavities require division before the stones can be removed. The methods of establishing a temporary fistula into the gall-bladder have undergone a number of changes. The edges of the wound in the viscus were at first sutured to the skin, later to the aponeurosis or to the peritoneum. The resulting fistula was almost always slow to close and sometimes failed do so; hence surgeons sought to invert the edges of the gall-bladder wound so that on removal of the drainage

hich was and is always used, peritoneal surfaces would be left in and healing be rapid. W. D. Jones devised a suture for inverting s of the gall-bladder wound and attaching it to the parietes. He he viscus well out of the abdomen and sutured it to the parietal um at a distance from the wound in it (Fig. 697). He next passed suture through the abdominal aponeuroses and muscles into the gall- near the line of stitches already in place; with this catgut suture he p the edges of the wound in the gall-bladder and brought it out through etes in the reverse direction to that in which it was introduced. When such sutures have been inserted and tied the cystostomy wound is properly inverted.

J. E. Summers' method of securing inversion and suspension is sufficiently shown in Figs. 698, 699.

The Mayos attain the same end as follows: Prepare a drainage-tube by surrounding it with a few layers of gauze covered by rubber tissue.

FIG. 698.

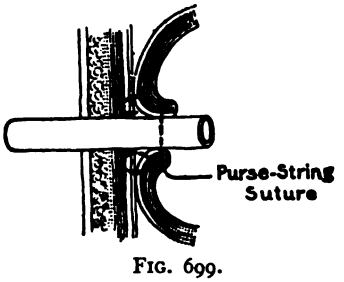


FIG. 699.

FIGS. 698 AND 699.—Cholecystostomy.

of the tube should be bevelled or trimmed in the "fishtail" fashion. In- this "dressed tube" a short distance into the gall-bladder. With atgut suture the edges of the gall-bladder wound snugly to the tube. e tube a little further into the gall-bladder, thus inverting that portion all-bladder around the tube and the original line of suture. With a t suture of catgut attach the surface of the gall-bladder all around to the tube. Leave the ends of this last suture long, and with a needle hem to the parietal peritoneum.

advantages of this procedure are: (*a*) The purse-string suture prevents of bile around the drainage-tube. (*b*) When the tube is withdrawn, rsion of the bladder wound leaves serous surfaces in contact, there is pse of mucous membrane, and hence closure of the fistula is hastened. merous small calculi and much biliary "sand" have been removed, it is to invert the edges of the wound in the gall-bladder, since by so doing formed which will prevent the discharge of any "sand" or small stones y have been overlooked.

the gall-bladder could not be brought, without tension, into contact rietes it was found that if the tube was well sutured into the viscus could be safely dropped back into the abdomen and the tube brought

out through the parietes exactly as is done in drainage of the cystic or common ducts. As a precautionary measure it may be well to surround the tube, in its passage through the peritoneal cavity, with a little gauze protected by rubber tissue. This precaution is probably entirely unnecessary as the omentum, that most efficient "abdominal policeman," will certainly surround and isolate the tube. At present the best method of performing cholecystostomy seems to be: (1) Evacuate the contents of the gall-bladder by aspiration, incision or both. (2) Surround the cystotomy wound by a continuous catgut suture penetrating all the coats of the viscus. Introduce a "dressed tube" into the gall-bladder and tie the catgut suture, already in place, snugly around it. Introduce a purse-string suture of catgut, in the Lembert fashion, into the walls of the gall-bladder, around and a short distance away from the tube. Push the tube farther into the gall-bladder thus causing invertion of the original line of suture. Tighten and tie the purse-string suture. With a needle make the purse-string suture take one or two bites in the drainage tube to anchor the latter. Instead of a "dressed tube" one may use a rubber tube, the end of which has been turned back on itself twice in a double revere. If this tube is used the purse-string suture snugly tied round it just above the revere, which is in the bladder, will prevent it escaping (Fig. 700). (3) Permit the gall-bladder to assume whatever position it pleases, in the abdomen. Bring the end of the drainage tube out through the parietes. (4) Close the abdominal wound with or without further drainage. The tube may be removed whenever it becomes loose.

FIG. 700.—Rubber tube with a double revere introduced into gall-bladder.

X–X, Suture around wound in gall-bladder; Y–Y, purse-string suture.

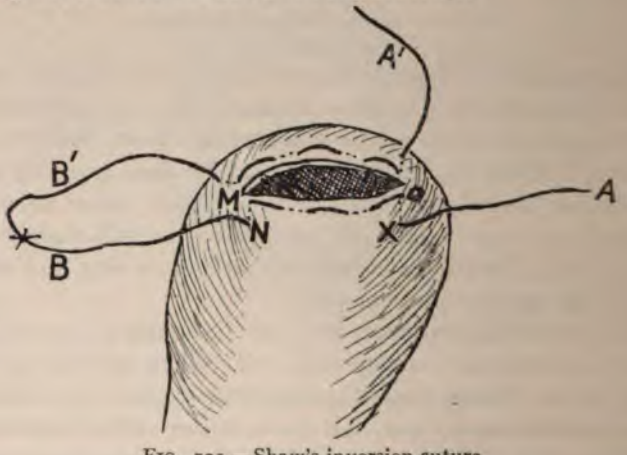


FIG. 701.—Shaw's inversion suture.

Shaw's inversion suture is good (Surg., Gyn. and Obst., June, 1916).

Introduce suture *A* (Fig. 701) at *X* about ⅜ inch from the edge of the opening in the viscus, let it emerge a *O* about ⅛ inch from the edge of the opening. Continue the suture from *O* to *M* each bite penetrating the whole thickness of the wall of the gall bladder. Let the last stitch emerge at *N* a point corresponding to *X*. Continue the suture *BA* on the opposite side of

the opening. Cut the loop *BB*. Introduce the drain. Pull upon and tie *AA* while the assistant at the same time tightens and ties *BB*. Easy inversion results.

Cholecystectomy.—Is called for under several conditions such as the presence of neoplasms, lithiasis, and inflammation, but the indications necessitating it will be discussed later.

Step 1.—Exposure and exploration of the gall-bladder and ducts.

Step 2.—Aspiration or incision of the gall bladder is necessary under the following circumstances (Monod and Vanverts): (1) When the viscus is so distended that it is liable to rupture during the necessary manipulations. (2) When external exploration of the common duct leaves doubt as to its permeability and one desires to catheterize the ducts through the bladder. One must remember, however, that the valvular construction of the upper part of the cystic duct does not lend itself to easy catheterization.

In the absence of the above conditions it is better not to open the viscus so as to avoid possible contamination of the wound.

Step 3.—When, as exceptionally happens, the gall-bladder is provided with a "meson," divide this between ligatures or forceps. As a rule, the viscus is applied directly to the undersurface of the liver and held there by the peritoneum, and one operates as follows: Incise the peritoneal covering of the gall-bladder and by blunt dissection separate the organ from the liver. Bleeding from the liver may be controlled by suture, by the use of the Paquelin cautery, or by the sponge pressure. Isolate and ligate the cystic branches of the hepatic artery; ligate and divide the cystic duct. If it is desired to drain the biliary passages, only one ligature or clamp may be applied between the gall-bladder and the point of section of the duct; if complete closure of the passage is sought, then the duct should be divided between two ligatures. Riedel under the latter circumstances closes the abdominal wound without drainage, but most surgeons prefer to drain with a small roll of rubber tissue or dental dam. The peritoneal flaps left after removing the gall-bladder ought to be sutured. If drainage of the duct is required or desired, leave the stump of the duct open and suture over it or to it a rubber drainage-tube with a stitch of fine plain catgut. This stitch will be absorbed before it is time to remove the tube, and in the meantime will hold it in place.

Undoubtedly cholecystectomy is best accomplished from below upwards—*i. e.*, beginning by dividing the duct. There are two principal reasons for this: (*a*) The dissection is easier; (*b*) the cystic artery (generally two branches) is ligated at the same time as the duct and thus hemorrhage is completely controlled at the earliest possible moment. The only objection to this method of removal is that the operator may fear mistaking the common for the cystic duct.

The Operation.—*Step* 1.—Expose the gall-bladder by any convenient incision; the author prefers one more or less transverse. E. S. Judd writes: "The abdominal incision, instead of being made over the normal location of the gall-bladder, is made high and close to the mid-line, usually extending to the ensiform. Through this high incision, in most cases, much of the right lobe of the liver can be rolled out by using the gall-bladder as a tractor. If the liver

is adherent to the parietal peritoneum, the adhesions should be freed before proceeding further, as the operation is much simpler if the liver can be displaced."

Step 2.—Explore the common duct, the head of the pancreas and the neighboring lymphatic glands. The dissection necessary for this exploration exposes the cystic duct.

Step 3.—Apply a forceps to the fundus of the gall-bladder and gently pull it forwards and upwards. Apply a second forceps to the neck of the viscus; traction on this pulls the cystic duct away from the liver. By blunt dissection clear away any fatty and œdematous tissue which obscures the duct. Using

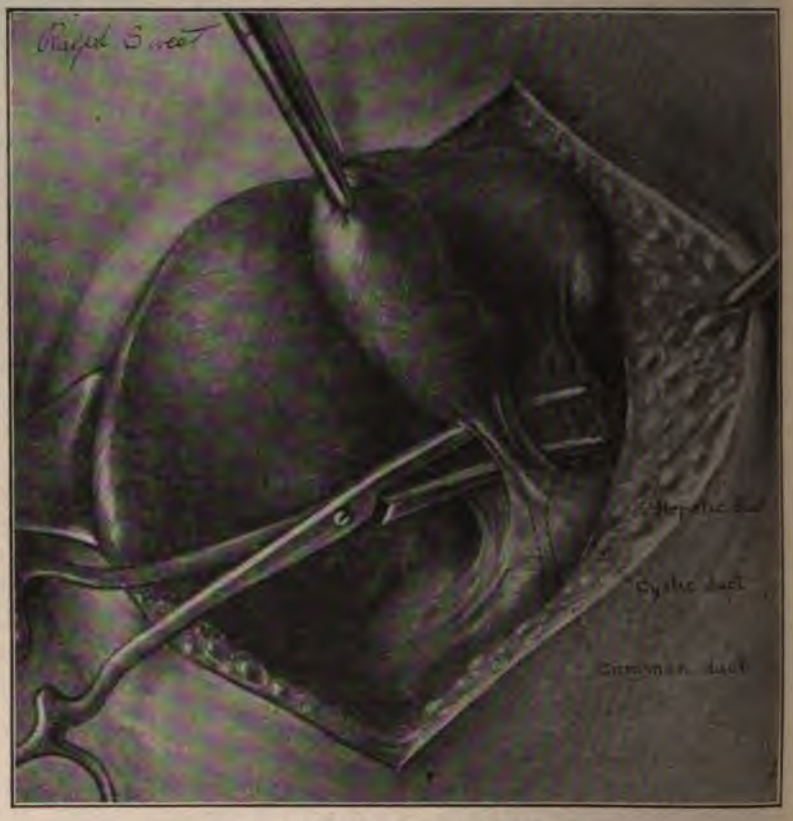


FIG. 702.—(*Judd, Annals of Surgery.*)

the cystic duct as a guide expose its junction with the common duct. "The neck of the gall-bladder and the lowest part of the body of the gall-bladder frequently lie along side the cystic duct, so that when this is dissected out and pulled up, the cystic duct is easily separated from the surface of the liver (Fig. 702)."

Step 4.—Isolate the cystic duct and the cystic artery *together* for about ½ or 1 inch and doubly clamp them together. Divide between the clamps.

Step 5.—Make traction on the forceps applied to the cystic duct beside the gall-bladder and so make prominent the peritoneal folds attaching the

der to the liver as well as the communicating vessels which are now easily rolled. Dissect the gall-bladder from the liver, leaving however enough of ndus attached so that it can be used as a tractor during the next step of the ation (Fig. 703).

FIG. 703.—(*Judd, Annals of Surgery.*)

Step 6.—Ligate the Stump. This can be done without tension and without ger to the common duct because of the thorough dissection. Suture the edges of the peritoneal folds from beside the stump up to the edge of the r, removing the gall-bladder little by little as the sutures are being inserted. e a small cigarette drain or roll of rubber dam down to the stump of the ic duct and along the fissure from which the gall-bladder was removed . 704).

Cholecystenterostomy.—When the common duct is irreparably occluded *e.g.*, by malignant disease, or when it is desirable to drain the ducts in chroni pancreatitis, the formation of a fistula between the gall-bladder and the gu permits the escape of bile. This operation is cholecystenterostomy.

(A) *Antero-colic method.* When possible, it is best to unite the gall-bladde to the duodenum but under stress of circumstances that portion of the intestin (even the colon) which is most readily brought up against the gall-bladder i the best portion to use. The operation itself is practically identical with that

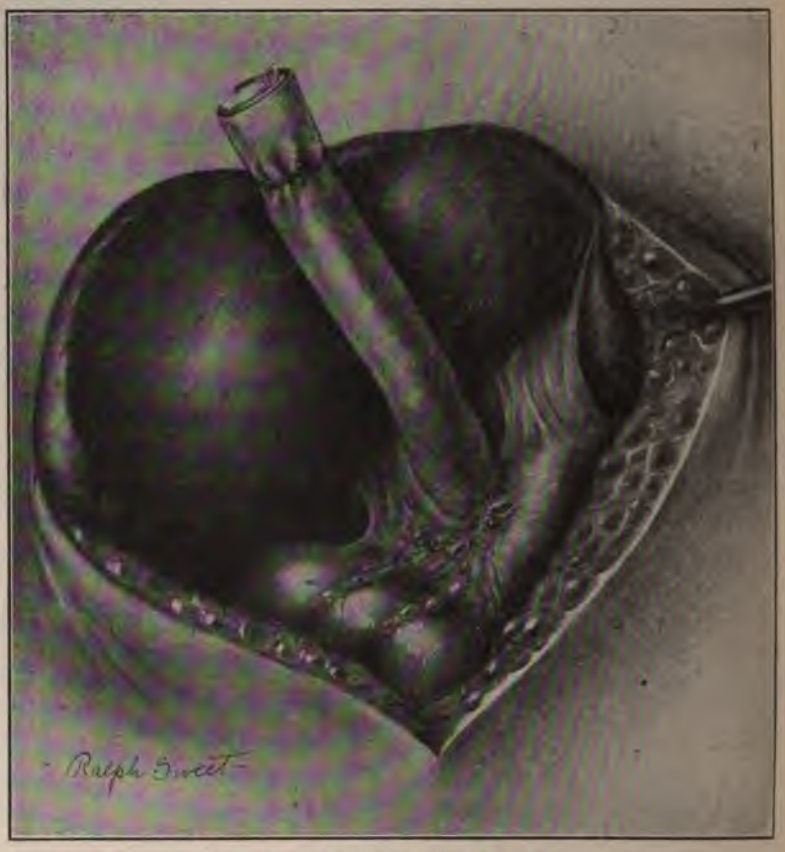


FIG. 704.—(*Judd, Annals of Surgery.*)

of entero-enterostomy (intestinal anastomosis) and requires no special descrip tion. It may be accomplished by the method of suture, by McGraw's elasti suture, or by the Murphy button. Probably the oldest patient ever submitte to this operation was a woman eighty years of age, in whom the author success fully used the Murphy button. Before the operation of choledochotomy wa as safe as it is to-day, cholecystenterostomy was much more frequently resorte to than at present; it averted the evils from obstruction of the common duct b stones, but it did not rid the patient of the obstruction itself or of the late effect of the irritation from the obstructing calculus.

When the gall-bladder is anastomosed to a segment of small intestine, it been suggested that an anastomosis between the afferent and efferent ients of the gut would prevent all possibility of intestinal contents gaining ss to the gall-bladder. This precaution seems, to the author, superfluous. t would not prevent the passage of the ever-present infection from the stine into the gall-bladder, even if it did keep the gross contents of the in- ine from entrance into that viscus. The increased danger of the extra ration seems out of proportion to the benefit to be obtained.

(B) *Retro-colic Method.* (Brentano, "Zentralblatt für Chir.," 1907, No. . Lotheisen, *idem.*, No. 31.)

Step 1.—Open the abdomen. Explore the gall-bladder and ducts.

Step 2.—Pull the transverse colon and great omentum out of the wound nd turn them upwards exactly as in posterior gastro-enterostomy. Find he duodeno-jejunal junction; select a portion of jejunum about 12 inches below the junction; select a bloodless portion of the transverse mesocolon close to the gall-bladder and tear a hole in it as in gastro-enterostomy. Pull the selected loop of jejunum, from below upwards through the rent in the mesocolon. Apply an intestinal clamp (*e.g.*, Doyen's) to the jejunum. Return the colon and omentum into the belly.

Step 3.—If the gall-bladder is distended empty it by means of a trocar and cannula introduced at its dome. Close the puncture.

Step 4.—Choose a suitable portion of the undersurface of the gall-bladder and to it apply an intestinal clamp. Lay the clamped loop of jejunum against the clamped loop of gall-bladder and make an anastomosis. If the Murphy button is used it is unnecessary to clamp the gall-bladder.

Step 5.—Once more pull the colon and omentum upwards so as to expose the transverse mesocolon. Pull the jejunum downwards until the line of the anastomosis becomes visible below the rent in the mesocolon. With a few stitches tack the edges of the rent in the mesocolon to the line of anastomosis. Return the colon and omentum to the abdomen.

No argument is necessary to show the superiority of the retrocolic method of cholecystenterostomy over the older method.

Cysticotomy—Incision into the Cystic Duct.—When calculi are present in the cystic duct, it is often possible to extract them through the gall-bladder. If this is not easy to accomplish, one should not waste much time in so doing, but should carefully locate the stones, incise the duct lengthwise directly over them, and extract them. The wound in the duct may be closed by sutures. The sutures, if of silk or hemp, must not penetrate the mucous membrane, lest nuclei of more calculi. Catgut sutures are excellent and have no disadvantage. Many surgeons insert but do not tie the sutures until the stones are removed. The suturing is not always difficult as might be supposed, since from disease the ducts are dilated and their walls [illegible] One must remember that [illegible] The writer has seen death result from [illegible] Very quick and good results are obtained by the use of [illegible] Mayo's combination of suturing with [illegible] duct and [illegible] this with a [illegible]

and is eminently safe. On the whole, the inexperienced operator is ad to avoid attempts at suturing the ducts.

Instead of making a separate incision into the duct one may follow agenière's plan of continuing the incision, already existing in the gall-bla downwards so as to split the cystic duct until the stone is exposed. If nece the whole length of the duct may be split in the above fashion. Te Hartmann and others, when dealing with stones in the *common* duct, the gall-bladder, cystic duct and as much of the common duct as may be n sary to expose and remove the stone, after which they remove the gall-bla pass a rubber drain far up the hepatic duct (Kehr's "hepaticus drain and pack a little gauze around the tube. The tube and pack are br out of the abdominal wound, the excess of which is closed. It is a wise caution to anchor the drain and pack to the ducts by fine catgut sutures.

The advantages of splitting the gall-bladder and ducts are that they an infallible guide to the stone and the wide opening permits of very exploration. The disadvantages are the difficulty of doing the work many adhesions are present, and the extent of the wound inflicted. On se occasions the author has found the procedure very useful.

Choledochotomy—Incision into the Common Bile-duct.—The cor bile-duct may be considered as consisting of two parts: one, supraduod stretching from the junction of the cystic and hepatic ducts to the uni the first and second segments of the duodenum; the other part, retroduod stretching the remainder of the distance to the ampulla of Vater.

The supraduodenal portion of the choledochus is about ¾ to 1 in length and occupies the right margin of the gastro-hepatic omentum. the left and behind the duct lies the portal vein—further to the left is the h artery. When the duct is dilated by disease, the portal vein may lie in of it. The dangers from this source have been grossly exaggerated operations the portal vein and hepatic artery are rarely seen. The l safe incision is along the anterior and right side of the duct. The for of Winslow is the guide to the duct. A finger passed into the forame hooked forwards inevitably brings the duct forwards also. Unfortun the foramen of Winslow is sometimes hidden or obliterated by adh Several lymphatic glands exist in the gastro-hepatic omentum, and enlarged may lead to error. The retroduodenal portion of the cholec runs for a distance of about 2 inches along the posterior-internal bor the second part of the duodenum. The duct for about 1¼ inches it reaches the ampulla of Vater lies on or in the pancreas. It is evider the retroduodenal portion of the duct covered by intestine and panc out of reach of palpation by ordinary means. To add to the difficulties, s lymphatic glands, prone to enlargement, exist along this tract and a positive diagnosis as to the presence or absence of stone impossible w further exposure. Vautrin ("Revue de Chirurgie," June, 1896) has an extremely exhaustive and important study on the anatomy and s of the retroduodenal choledochus, and the following is based on his w

Exposure of the Retroduodenal Choledochus (Vautrin's Operation).— traction on the second or descending portion of the duodenum. This

prominent the junction of the intestine and the gastro-hepatic omentum. Beginning at this prominent point, incise the peritoneum parallel to the convexity of the duodenal angle, and prolong the incision along the external border of the second segment of the duodenum, so as to free it from its external serous attachments. This soon exposes that portion of the duct which lies in a groove on the anterior surface of the pancreas. Lower down the duct is embedded in the pancreas and the exposure is more difficult, as various lobules of the gland lying between the duct and the intestine are closely adherent to the muscular coats of the latter. Blunt dissection alone no longer avails; the scissors must be employed and portions of pancreatic tissues must be sacrificed rather than intestinal wall. One and one-fourth inches of the duct may be exposed as above. A further exposure may be made, but to do this the thermocautery ought to be employed because of the numerous veins present. By the above measures the duct can be exposed to a point about $\frac{3}{8}$ inch from the ampulla of Vater.

Without previous knowledge of Vautrin's researches Cooper, of San Francisco, came to almost identical conclusions from his studies on the cadaver ("Annals of Surgery," vol. ii, 1903). Abbé also describes a similar method.

Jurasz (Arch. f. klin. Chir., civ, 1118) reviews the 104 operations in Payr's clinic in which Vautrin's method was used. The mortality was 8.5 per cent. In 18 there was dilatation of the choledochus from chronic pancreatitis without stone and in one cancer of the pancreas. In 26 cases of stone in the ampulla of Vater or in the retro-duodenal choledochus it was possible to coax the stone into the upper parts of the common duct except in one instance when duodenotomy was done. In 30 cases having a history of previous icterus the permeability of the duct was verified and in 23 this exploration was made in the presence of jaundice.

When the finger, passed through the foramen of Winslow, palpates stones in the upper portion of the common duct and the stones cannot *easily* be coaxed back into the gall-bladder for removal—how should they be treated? In the earlier days of the surgery of this region several plans were devised, and under exceptional circumstances might, even to-day, be practised.

1. The stones can be crushed *in situ* between the blades of forceps protected by rubber tubing. This treatment is, of course, liable to injure the duct-walls, and in spite of careful cleansing of the duct through the gall-bladder is certain to leave detritus which may or may not be passed *per vias naturales*.

2. Needles may be passed through the duct-walls and into the stones so as to facilitate their fragmentation. The same objections apply here as to the cholelithotrity by forceps.

3. The stones may be left *in situ*, and, the cystic duct and gall-bladder being free, the operation of cholecystenterostomy may be performed. This overcomes the dangers of biliary obstruction, but does not obviate the dangers inherent to the presence of retained duct stones, viz., irritation leading to inflammation and malignant disease.

The operation of choice is choledochotomy, or incision into the duct directly over the stone. The portion of the duct affected, exposed a

described, is grasped or steadied by the fingers, and an incision is made along it, over the stone, of size sufficient to permit of the easy extraction of the calculus. If it is desired to close the duct wound with sutures, such should be introduced but not tightened before the stone is removed. The stitches, if of silk, include the serous and muscular coats of the duct, but not the mucous. Comparatively few surgeons use sutures, preferring to rely on drainage until such time as closure of the duct takes place naturally. Having opened the duct and removed the calculi present at the site of incision, pass a probe downwards to the duodenum to insure the patency of the duct below, and upwards into the hepatic duct to explore for any calculi there present. This is the advice usually given, but it is, in fact, impossible by means of the probe positively to exclude the presence of stones; only by palpation with the finger inside the duct can positive knowledge be attained. Kehr strongly recommends that a rubber drain be passed up into the hepatic duct so as to provide exact drainage. Most surgeons pass a rubber drain down to the duct, fix it there with a stitch of plan catgut, surround it with a pack of gauze covered by rubber tissue, and close the external wound except where the drain and pack emerge.

Even if the wound in the duct be sutured, drainage is essential. When the gall-bladder has been opened, it may be treated in various ways: (*a*) It may be excised—cholecystectomy. (*b*) The opening in it may be sutured to the parietes—cholecystostomy. (*c*) It may be drained in the same fashion as the common duct is drained.

The Mayo brothers have systematized the operation of choledochotomy in the following manner:

Step 1.—Open the belly by the Robson incision. Separate adhesions and explore the gall-bladder and ducts. If the gall-bladder is distended remove part or all of its fluid contents by the trocar and cannula or by incision. The gall-bladder in case of common-duct stone is commonly much shrunken.

Step 2.—Pull part of the liver out of the wound and towards the right. This exposes the ducts and brings them within reach. Protect the belly cavity with gauze packs. With the fingers palpate the stone in the duct, and steady it so that it can act to the duct the part of a ball thurst into a stocking that is being darned. (Elliot.) Introduce, *longitudinally*, two fine plain gut sutures into the duct (Fig. 705). These penetrate the whole thickness of the duct-wall, if such is necessary to get a firm hold. Using the sutures as tractors, make an incision into the duct over the stone. Extract the stone. Explore the duct with the finger in it. The finger passed up the duct and pulled out again (slightly crooked when being pulled out) acts as the piston of a pump and sucks down any small stones which may be in the upper part of the common or in the hepatic ducts. In the large majority of cases the finger can and must be passed up to the division of the hepatic duct and down to the papilla; this can be much simplified by exerting counterpressure on the duodenum and pancreas. Ducts not large enough to admit the finger are usually thin-walled, not much adherent, and hence palpable from the outside. It is only in difficult cases, *i.e.*, where many adhesions are present and the duct-walls are thickened, that finger exploration inside the duct be-

mes absolutely necessary. In all cases when it is possible, this method exploration should be used. Diverticula hide stones from the probe or oop, as the nature of the calculi lets them give no feeling of "grit" when uched by metal; only the finger can recognize them.

Step 3.—Treatment of the wound in the duct.

(A) If it is possible to do a cholecystostomy, and the cystic duct is sufficiently tent to permit of biliary drainage, the wound in the duct may be treated follows: Cross the one end of suture x with that of suture y (Fig. 706), d the end of suture x^1 with that of suture y^1 but do *not* tie them. Place

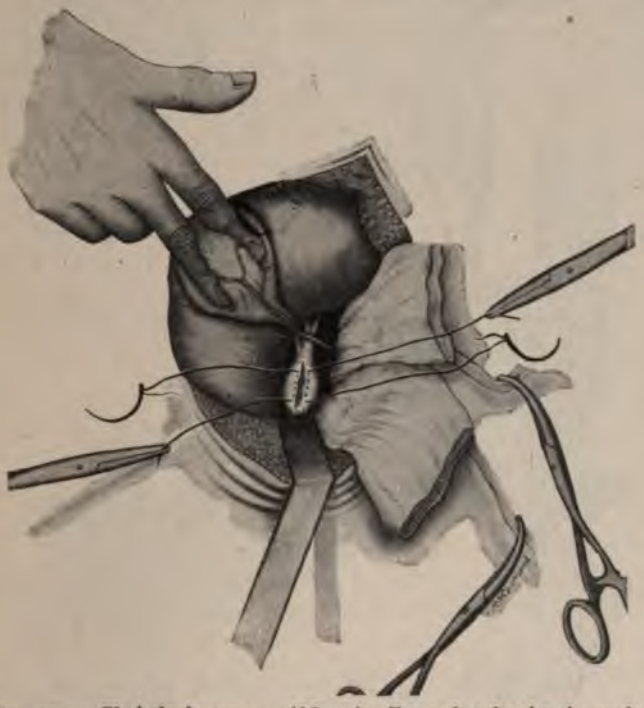


Fig. 705.—Choledochotomy. (*Mayo.*) From sketches by the author.

e strip of gauze g (Fig. 707) longitudinally over the wound in the duct and er the crossed sutures. Tie the sutures around the gauze strip, the free e of which is covered by a layer of rubber tissue. This closes the wound d fixes the gauze over it, so that should bile escape it cannot wash away gauze and, an efficient drain is provided. Bring the end of the gauze out ough the abdominal wound. A folded strip of rubber dam or gutta-percha sue is preferable to the gauze. Establish a cholecystostomy. Close the cess of abdominal wound.

(B) If owing to the small size or the diseased condition of the gall-bladder cholecystostomy is impossible or improper, proceed as follows: Prepare ¼-inch tubular drain wrapped with gauze to within a distance of ⅓-inch its end. Introduce the bared end of the tube *into* the common duct; the vering of gauze prevents its going in too far. Thread one end of the suture

X–X¹ on a needle, pass it through the tube and tie it to the other end of the same suture. Do the same with suture Y–Y¹. Bring the end of the drain out of the wound and close the excess of abdominal wound (Fig. 708). The end of the tube introduced into the duct should be beveled or cut in the "fishtail" fashion. A small gauze pack around the above and tied to the suture Y–Y¹ or X–X¹ is an

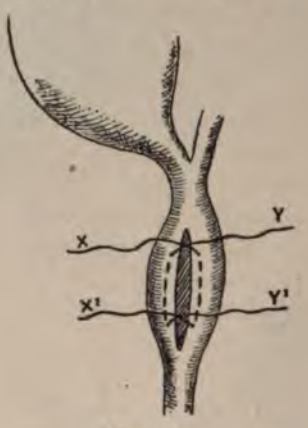


FIG. 706.

FIG. 707.

FIGS. 706 AND 707.—Treatment of incision in common duct.

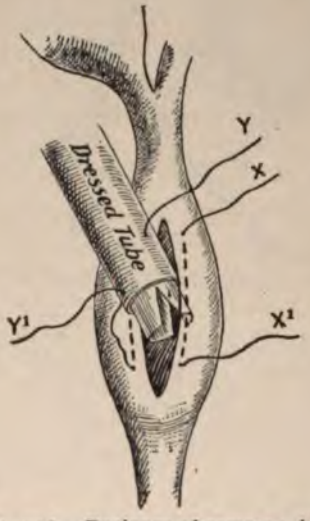


FIG. 708.—Drainage of common duct.

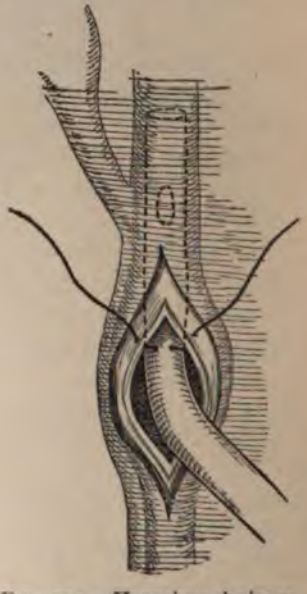


FIG. 709.—Hepaticus drainage.

added safety. McArthur introduces a rubber tube into the duct but directs it *towards* the duodenum instead of towards the liver. The caliber of the tube must be less than that of the duct. The object of this radical change in method is that solutions of any appropriate kind in any desired quality can be introduced practically directly into the duodenum. In cholemic nephritis with anuria the introduction of 1, 2 or even 3 liters of hypotonic salt solution has saved a

ıber of otherwise hopeless patients. In acute septic nephritis Matas has ormed cholecystostomy on the normal gall-bladder and saved his patient instilling much warm Vichy Celestin.

(C) Hepaticus drainage. Through the wound in the common duct in- luce a drainage tube upwards to beyond the opening of the cystic duct. best tube to use is a soft-rubber catheter (No. 25 to 30 F.), with its end off and a lateral opening made about ¾ inch from its extremity. Fix tube to the wound by a catgut stitch (Fig. 709). Close the excess of the und in the duct and the hepato-colic omentum by a continuous catgut ch. Drain the gall-bladder with a dressed rubber drain. Between the k of the gall-bladder and the wound in the common duct, place a strip iodoform gauze. With fine catgut stitch the end of a large split rubber e to the common duct immediately below the exit of the drain. (The

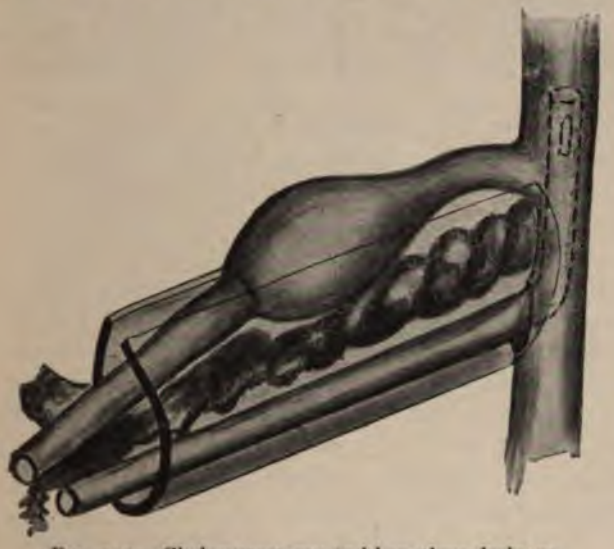


FIG. 710.—Cholecystostomy and hepaticus drainage.

e suture used for closing the duct wound is suitable for fixing the large tube.) Make the split tube embrace or almost embrace the common duct n, the gall-bladder drain the strip of gauze and any other drain which be required (Fig. 710). Tie a thread of catgut round the split tube so o hold all these drains together, and let them all protrude, as one, through abdominal wound.

Another method of reaching the calculus, viz., by splitting the gall-bladder both the cystic and common ducts, is described under cysticotomy.

When the obstructing calculus exists very low down in the common duct, may reach it by the transduodenal route. McBurney ("Annals of Sur- ," Oct., 1893) was the first to perform this operation of *duodeno-choledo- omy*. Kocher is a supporter of the method. Mayo Robson thus describes procedure:

"The termination of the common duct, including the duodenum, should grasped between the finger and the thumb of the left hand and the anterior

wall of the gut cut through, thus exposing the interior of the posterior wall of the intestine with the termination of the common duct running in it. Either the duct can be laid open from the papilla, or the stone may be cut down on, through the posterior wall of the duodenum. Bile flows freely as soon as the obstruction is removed, and it must be mopped away as it flows, since it always contains pyogenic microbes and is therefore infective. As a rule, there will be no trouble with bleeding and no sutures need be placed in the posterior wall of the duodenum. The incision through which the duodenum has been opened should be sutured by a continuous catgut suture for the mucous membrane and a continuous silk suture for the peritoneum. No drainage is required. For calculi situated in the lower third of the common duct, especially if impacted in the diverticulum of Vater, the operation is decidedly preferable to the ordinary choledochotomy, as not only is it easier, but an incision of the narrow orifice of the bile-duct in the duodenum leaves a patent opening, which will allow any other concretions that may have escaped observation to pass without difficulty." ("Dis. Gall-bladder and Bile-ducts," 1901, p. 269.)

Sencert ("Revue de Gynécologie et de Chir. Abdom.," x, 47) gives the following anatomical rules for finding the ampulla of Vater by the duodenal route. (*a*) Observe whether the ascending colon is fixed or is provided with a mesocolon. (*b*) If the ascending colon is fixed (80 per cent.), incise the duodenum transversely immediately above that portion or angle of the colon which lies on its anterior surface. (*c*) If the ascending colon has a meson (20 per cent.), find the root of the transverse mesocolon and incise the duodenum immediately above this. This leads directly to the ampulla of Vater.

J. C. Hancock ("Annals of Surg.," Jan., 1906) has collected 62 cases in which the common duct has been reached through the duodenum. The death rate was 12.6 per cent. In 57 of the cases operation was for the removal of gall-stones, in 2 for the relief of neoplastic obstruction of the papilla and in 2 for the removal of pancreatic calculi.

Kehr and Mayo have supplemented the operation by opening the common duct high up and pulling strips of gauze through the duct from one opening to the other, thus insuring the removal of all fragments of stone.

Hepato-cholangio-enterostomy.—This operation consists in effecting an anastomosis between the gut and the smaller hepatic ducts. It is indicated in those cases in which there is present permanent obstruction of the common and main hepatic ducts or of the common and cystic ducts. Under the above circumstances a cholecystenterostomy would be useless, and a cholangiostomy (*i.e.*, a union of the opened small bile-ducts to the skin) as practised by Kocher and Langenbuch is objectionable, as it establishes a permanent biliary fistula. Hepato-cholangio-enterostomy was suggested by Baudouin, and Langenbuch, but first practised by Hans Kehr. ("Centralblatt f. Chir.," 1904, No. 7.)

The Operation.—Step 1.—Exposure of gall-bladder region, preferably by Mayo Robson's incision. If necessary, excise the gall-bladder.

Step 2.—From a convenient part of the lower margin of the liver excise a strip of liver tissue about two and one-half inches long by about one inch wide. With the thermocautery stop the hemorrhage and at the same time burn a hole in the liver of such a depth that several moderate-sized bile-ducts are opened.

3.—Choose a segment of gut, preferably duodenum, which can be up to the hepatic wound without tension. In this gut make an opening ies long, and suture it to the margins of the liver wound. In Kehr's y a few sutures cut loose while being tied, and he was able to close the thout packing the wound. In most cases one imagines that packing oform gauze, or at least the use of one or more cigarette drains, would uch value. In the case operated upon recovery ensued and the liver emed to tolerate the necessary direct contact with intestinal contents. van ("Trans. Surg.," Sect. A.M.A., 1912) has excised the common duct ınd restored the continuity of passage in the following manner: Push a ɔer tube not less than ¼ inch in *inside* diameter *into* the hepatic duct t there by two or three non-absorbable sutures. Push the other end of : through the stump of the common duct into the duodenum for not ın 1 inch. If the stump of the duct is not available, close its remnant ure or ligature; puncture the duodenum, introduce the tube through the : and fix it there with sutures, inverting the edges of the duodenal ound the tube. Lay the exposed portion of the tube along the surface uodenum and by means of sutures bury it in the duodenal wall exactly ne in Witzel's gastrostomy or in cæcostomy. Unite that portion of between the hepatic duct and the duodenum to the edge of the gastro-ɔmentum. Pull up the great omentum and completely cover the rubber h it. Fix the omentum in place with sutures.

rk.—Is it not very probable that infolding of the duodenal wall might ıch diminution of the lumen that a gastro-enterostomy might be y?

ns ("Berliner klin. Woch," 1912, No. 12) reports five cases in which he ted a rubber tube for the common duct with good results. His method r to that of Sullivan.

. Mayo finds that jaundice recurs in the course of a year or two after rently successful operation of this kind, due presumably to stenosis ıther unnatural new passageway."

n the common duct has become closed and a cholecystenterostomy vailable the common or the hepatic duct may be anastomosed to the m. If the duct is much dilated it may be united to the gut by lateral osis. If this is impossible the duct may be divided transversely; the m, mobilized after the manner of Vautrin, Cooper, Finney or Kocher, lifted up to lie without tension near the open duct and united by a few titches to the tissues beside the duct. It is now possible to make an ide anastomosis between the duct and the duodenum (W. J. Mayo, of Surg., July, 1905).

McArthur in 1908 performed an operation which has been subsequently lependently devised by Wilms and others. Expose and divide the the site of stricture; ligate its duodenal end. Insert into the open end of the duct a small rubber drainage tube the end of which has ice turned back on itself, making a double revere. Pass 3 or 4 inches ther end of the tube into the duodenum through a small opening around purse-string suture has been inserted. Tie the suture snugly around ıe stump of the duct covering the rubber drain, to the

duodenum. The result is an end-to-side anastomosis. The rubber tube when it has served its purpose escapes per rectum in a few weeks.

A. J. Walton (Surg., Gyn., Obst., Sept., 1915) where direct anastomosis was impossible, performed a plastic operation successfully as follows: Insert a rubber tube into the duct and fix it there with a catgut suture (if the tube has been soaked for a few days in liquid paraffin, as advised by McArthur, it will not permit coagulation of the bile in it). From the anterior surface of the duodenum reflect a flap *downwards*, long enough to reach to the duct and wide enough to surround it without tension. Close the wound in the duodenum leaving enough of it open, beside the pedicle of the flap to admit the end of the tube. Insert the end of the tube into the duodenum. Pull the duodenum as near to the duct as possible and anchor it with sutures to any convenient tissues. Suture the flap around the tube and to the duct. This operation is very similar to one of v. Stubenrauch's but the flap has its pedicle below and the end of the tube is *not* brought out through a second puncture in the gut.

v. Stubenrauch's Methods.—Very rare cases occasionally arise in which owing to a small size of gall-bladder, adhesions in the operative territory, immobility of the omentum (*e.g.*, because of herniæ, etc.) it is impossible to perform any of the ordinary direct anastomoses between the gall-bladder or ducts and the alimentary canal, and yet it is absolutely necessary to short circuit an obstructed duct.

FIG. 711.—Stubenrauch's operation.

v. Stubenrauch ("Archiv für klin. Chir.," lxxix, 1015) endeavored to solve the above puzzle in a case of chronic pancreatitis with complications in the following fashion: At a previous operation the shrunken gall-bladder and the common duct were both drained, leaving a fistula leading from the skin to the duct.

Method I.—Make an incision through the skin around the fistulous orifice. Separate the fistulous tract from its surroundings, leaving it connected with the common duct like a vermiform appendix. Make an incision into a convenient portion of the stomach or duodenum and implant the distal end of the fistulous tract into this. In v. Stubenrauch's case the implantation into the duodenum caused narrowing of the pylorus, so gastro-enterostomy was done. Result was failure due to necrosis of fistulous tract.

Method II.—Expose the openings in gall-bladder and common duct. Pack the common duct with gauze and see if the bile will flow into the gall-bladder; if it will, use the gall-bladder for the anastomosis; if it will not, then use the duct for this purpose. Expose the duodenum and pyloric portion of the stomach. From the duodenum and stomach reflect a flap with pedicle above, about 1 inch wide and long enough to reach without tension to the opening in the gall-bladder or duct. This flap consists of all the coats of the viscus (peritoneal, muscular and mucous) (Fig. 711). Turn the flap upwards. Occlude the opening in the common duct by laying the serous surface of the flap over it. Unite the distal end of the flap to the opening in the gall-bladder with a few

Close the wound in the stomach and duodenum, leaving room be at the base of the flap. Introduce a drain between the gut der. Partially close the external wound. Pack and drain. plete immediate success. About six months afterwards nd temporary evidence of local trouble.

:h *suggests* an improvement of Method II and also an alternate

-Make the gastro-duodenal flap as above, but unite its lateral inge-tube (Fig. 712) so as to form a tube lined with mucous te the free end of the flap to the opening in the gall bladder on duct as the case may demand) (Fig. 713). Make a small : duodenum a short distance distal to the flap and through nd of the drainage-tube emerge. Unite, with sutures, two l wall over the drainage-tube for a short distance exactly

FIG. 712. FIG. 713.

FIGS. 712 AND 713.—[illegible]

tion for gastrostomy (Fig. 713). [illegible] the wall of the stomach to the abdominal wound. [illegible] wick and drain the operative area. [illegible] r this method drainage [illegible] [illegible] [illegible]

about 4½ inches below the line of section (Fig. 714.) Make an incision through the skin alone, immediately below the biliary fistula. Introduce a forceps into this wound and burrow a canal between the skin and aponeurosis down to the laparotomy wound. With the forceps pull the end of the lower segment of gut (temporarily closed by a ligature) through the subcutaneous tunnel and unite it to the cutaneous opening of the biliary fistula. (It may be necessary to mobilize the end of the fistula slightly). Close the laparotomy wound, being careful not to constrict the portion of gut where it passes through

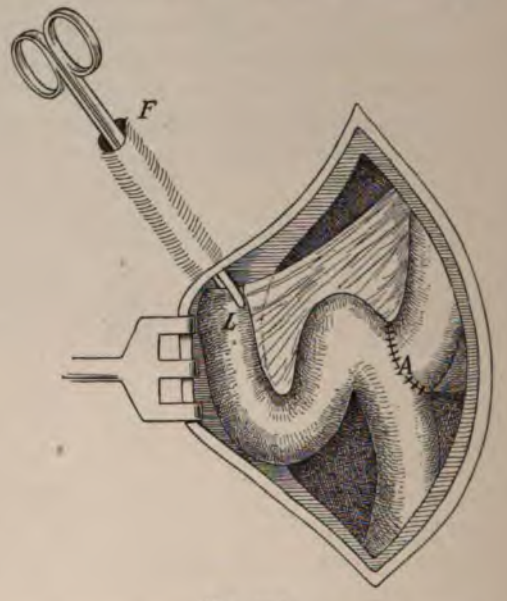


FIG. 714.

A. Anastomosis between end upper segment gut and side lower segment. *F*. Biliary fistula and incision through which forceps is passed subcutaneously to grasp and pull up to *F* the segregated portion of lower segment of gut *L*.

the deep structures of the belly-wall. It might be wise to supplement the longitudinal laparotomy wound by a small transverse incision through the rectus and aponeurosis at the point where the segment of gut passes through these structures.

The author used this method in one case (reported by Sutton, "Annals of Surg.," Sept., 1910). The segment of intestine passing under the skin to the fistula retained its vitality but acted as a fæcal fistula.

These methods of v. Stubenrauch have been suggested for certain rare and very difficult cases. Only one of the methods has been used with success. They are described here as they are worthy of consideration and *may* be helpful in an emergency.

INDICATIONS FOR AND CHOICE OF OPERATION

It is undoubtedly true that in at least one-half of all cases of gall-stone disease in which diagnosis has been made, an apparent cure may result from medicinal treatment. Scientifically such a "cure" is generally merely apparent,

ılculi remain *in situ*, but are at rest and give rise to no evident trouble. ient considers himself well, but he is always exposed to relapse, and inued presence of the stones is to-day believed to be conducive to malig- ease. Some surgeons believe that every case of gall-stone disease be submitted to early operation. Winiwarter was the first to pro- this dictum and Riedel takes much the same ground. W. J. Mayo t the successful passage of the calculus *per vias naturales* is not a con- ıtion but a positive indication for operation, as there are always more follow, and the next ones may become impacted in the common duct, essitating a grave instead of a safe operation. Few modern surgeons ıuch loss of time before operation is decided on. In the writer's ex- there have been a number of cases where the symptoms were ap- trifling, and yet exploration showed advanced disease. There is great and danger in operating upon many of the old cases; adhesions and ions alter the anatomy most confusingly, and all conceivable difficulties arly operation, before the common duct is involved, is easy, and on e very safe.

her cholecystostomy or cholecystectomy should be the operation of not entirely easy to answer. If the operation has been rendered owing to adhesions from old inflammation, etc., and if the surgeon has much experience, then undoubtedly cholecystostomy is the preferable The same is true in cases of phlegmonous cholecystitis or gangrene patient is too ill to bear cholecystectomy.

scussing the treatment of interstitial pancreatitis, Robson ("Surg., ostetrics," Jan., 1908) writes: "This brings into prominence the un- ty of removing the gall-bladder as a routine procedure in operating tones, for unless it is seriously damaged or ulcerated, or is the seat of t disease, or unless there is ulceration or stricture of the cystic duct, is quite unnecessary. I think it better practice to drain it simply to perform cholecystectomy, since on some future occasion, should evelop in the deeper ducts or in the pancreas, and the gall-bladder be t will be impossible, with few exceptions, to short-circuit the obstruc- oreover, after cholecystotomy gall-stones have no greater tendency to ıan they have after cholecystectomy, and should cholelithiasis again it will be in the common duct, a much more serious position than if ll-bladder."

cystectomy "is contraindicated in all cases of non-patency of the com- t, and it should not be resorted to under the idea that it will prevent ation of gall-stones, as calculi may form in the bile-duct, within the below it."

ell Park, S. J. Mixter and others have long urged that all diseased lers should be treated on the same principle that leads to removal ermiform appendix when diseased. All surgeons are widening the ıs for cholecystectomy and narrowing those for cholecystostomy. that carcinoma is found present in a considerable number of thick- -bladders is a great incentive to excision. Mayo finds that while ancreatitis becomes much improved after cholecystostomy yet when

the fistula closes the symptoms often recur and can be cured only by removing the gall-bladder.

C. A. McWilliams ("Presbyterian Hospital Reports," N. Y., 1906) in a careful analysis of the results and after-results of 186 operations upon the liver and gall passages finds the immediate danger of cholecystectomy to be 1.5 per cent. greater than that of -ostomy, but that the permanent results of the -ectomy are very much better than those of the -ostomy.

The question is often asked, Are gall-stones liable to form again after they have been removed by any of the above operations? The experience of Kehr, Robson, the Mayos, Riedel, and others, an experience amounting to many thousands of cases, teaches that if the calculi have been removed there is no recurrence. In the hands of less experienced operators apparent recurrences crop up, but these are usually cases of stones overlooked in the original operation. The younger practitioners must remember that operation is not directed merely against the gall-stones themselves, but against the infective processes which give rise to them and against the complications which they occasion. The author remembers well one case in which a complete cure attended the purely medicinal treatment of gall-stone disease, but the patient succumbed to the remote results of the lithiasis, viz., an extensive adhesive peritonitis causing obstruction of the first portion of the duodenum. Operated upon early, this case would have been easily cured; a late and compulsory operation was fatal.

Cholecystostomy may be indicated as a means of introducing into the duodenum directly, rapidly and repeatedly larger or smaller quantities of various liquids in the treatment of anuria, etc. (McArthur; Matas).

The indications for cholecystenterostomy have been sufficiently described in earlier paragraphs.

COLOHEPATOPEXY OR COLON SUBSTITUTION

E. W. Andrews ("Journ. Am. Med. Assoc.," Sept. 16, 1905) notes the severe gastric disturbances which follow wide adhesion between the liver and the anterior surface of the stomach. If these adhesions are separated they necessarily reform. Andrews endeavors to arrange matters so that where they do reform they will be harmless.

Step 1.—Exposure through a free right rectus incision.

Step 2.—Note the shape, position and mobility of the stomach. Usually numerous short bands or a broad adhesion will be seen between the liver and a large part of the pyloric end of the stomach. Divide or separate the adhesions at the expense, if necessary, of the liver rather than of the stomach. Inspect the patency of the pylorus by passing the finger through it in the usual fashion.

Step 3.—All adhesions having been freed and the stomach being in normal position, pull upwards the transverse colon and with it some omentum. Thrust these into the space between the liver and pylorus. Stitch the colonic omentum to the gastro-hepatic ligament. The more loose omentum can be interposed the better it is.

Andrews has had excellent results from this colonic interposition or suspension.

ATION FOR ECHINOCOCCIC CYSTS OF THE ABDOMEN

ococcic cysts are composed of a structureless true capsule or wall on surface of which there develop the young heads of the parasites. ty of the cyst is filled with thin fluid in which lie numerous subsidiary ter cysts. The whole cyst is surrounded by a firm connective-tissue leveloped from the liver itself. The cysts may be single or multiple, he former.

f 18 cysts operated on by Mabit the site of disease was: right lobe liver, be, 3; spleen, 2; omentum, 3; mesentery, 2. The liver being the organ ffected, the operations here described will have special reference to it. al methods of operating on echinococcic cysts have been recommended, t of them have been discarded in favor of more radical measures. n is ineffectual and dangerous. Injection of antiseptics—*e.g.*, bi- of mercury or formalin solution—is dangerous and indefinite. The hod of treatment is enucleation.

rding to the site of the disease access is gained to it by one of two routes:

Abdominal Route.—When the disease can be reached by this route, sually can, it is the preferable one. Open the abdomen by a vertical ue incision over the most prominent part of the tumor. Explore the ., to make sure of the diagnosis, to ascertain whether the disease is multiple and to satisfy one's self as to anatomical relations. With icks thoroughly isolate the field of operation from the peritoneal cavity. the edges of the abdominal wound with gauze. The firm false capsule yst will usually show prominently on the surface of the liver. Seize capsule with a stitch or a volsella. With a trocar and cannula empty of its fluid contents, thus rendering its walls flaccid. Pull the cyst- far as possible out through the abdominal wound and incise it freely. igers, strips of gauze, and salt solution gently evacuate *all* daughter If possible, peel the true cyst-wall from the false fibrous capsule, but ndeavor to excise the latter.

are a rubber tube by surrounding it with a few layers of gauze and cover ze with rubber tissue. Introduce this "dressed tube" into the cyst, h plain catgut suture the opening in the cyst around and to the tube. the field of operation and remove the gauze pads from the peritoneal Suture the cyst-wall, around the drainage-tube, to the parietal peri- Close the excess of abdominal wound.

condary cysts are present and lie close to that first opened, they may be ed from it. Sometimes several cysts may require to be opened through abdominal incisions. The advantage of sewing, with catgut, the open- e cyst around and to the drain is that all leakage into the belly is abso- voided. The catgut remains effective until union is so far advanced re is no danger of the peritoneum becoming soiled.

e surgeons perform the above operation in two stages. At the first they expose the diseased portion of liver, pack the wound, and wait more for adhesions to form and protect the peritoneum. At the they open the cyst and treat it as already described. There is

practically no greater danger in completing the operation at one sitting than in waiting for adhesions to take place, and if the cysts are multiple, the operation in two stages is entirely unsuitable.

The method of treatment outlined is known as marsupialization; its objectionable features are: long convalescence; the dangers of suppuration, and the persistence of biliary fistulæ. Marsupialization is an eminently safe operation.

Bond suggested that the cyst cavity might be obliterated by means of buried sutures, and the abdomen closed without danger. Other surgeons, after evacuating all the cyst contents, advise filling the cavity with iodoform emulsion or with saline solution, and closing it completely with suture. There is too much danger involved in this method to render it advisable. The experience of John O'Conor, Mabit, and others shows that the sutured false capsule of a hydatid cyst is very prone to suppuration, and that Bond's operation, however modified, is exceedingly dangerous. Mabit finds that if *much of the cyst-wall protrudes beyond* the parenchyma of the liver, spleen, or whatever organ it affects, such free cyst-wall may be excised and the remainder after being thoroughly dried, may be left with safety in the belly cavity. The operation of Mabit is improper unless at least ⅓ of the cyst-wall is free, and unless the contents are sterile as regards pyogenic organisms.

(B) **Transpleural Route.**—When the disease is situated far back on the dorsum of the liver, presses into the subphrenic region, and cannot be conveniently reached from in front, one gains access to it by the transpleural route.

The Operation.—Excise about three inches of the eighth or ninth rib in the anterior axillary line. Suture, with catgut, the parietal to the diaphragmatic pleura. Of course, in inserting these sutures one aims at uniting the two pleural surfaces alone, *i.e.*, without other tissues, but one never succeeds in so doing. The stitch, if effective, always includes in its loop other tissues than the pleura. Incise the diaphragm and expose the liver. Pack gauze all around the area of liver to be opened. Treat the disease as already described.

CHAPTER XLV

HERNIA

Herniotomy.—Formerly herniotomy was considered one of the most beautiful and satisfactory operations in surgery; now, however, it is rarely thought of as a complete procedure, but merely as a preliminary to some one of the operations for the radical cure of the hernia. Under the caption "herniotomy" will be convenient to describe the methods of combating some of the complications met in cases of irreducible and of strangulated herniæ.

1. *Incision.*—(A) *Inguinal hernia:* (*a*) Bassini's incision (page 605). (*b*) Macewen's incision (Fig. 715 and page 591). (*c*) Any more or less vertical incision over the hernial swelling and following its long axis. (*d*) Ferguson's incision (page 608).

(B) *Femoral hernia:* (*a*) Bassini's incision (page 596). (*b*) Vertical incision.

(C) *Umbilical and ventral herniæ:* Vertical or transverse incision.

2. The skin having been divided, one picks up the subjacent tissues layer by layer and divides them between forceps* (Fig. 716). By this method the hernial sac is soon reached. How may the sac be recognized? Bull says the sac "may be recognized, first, by the presence of the subperitoneal fat immediately outside it; second, by its lead or bluish color; third, by its gliding over the contents of the sac beneath it.

FIG. 715.—Herniotomy. (*Esmarch and Kowalzig.*)

FIG. 716.

While the sac in inguinal and femoral herniæ is being freed from its surroundings, especially when its neck is being isolated and dragged upon, it is not rare to pull the urinary bladder into the hernial canal. The bladder may be recognized by its musculature, and must of course be avoided. Brunner ("Deutsche Zeitsch. für Chir.," ci, p. 562) has observed this dragging down of the bladder in 44 out of 775 operations for inguinal and femoral herniæ.

Especially in a small hernia, the finding of the sac is sometimes a matter of difficulty. Remember that the sac is a protruding pouch of peritoneum, hence to find it, *e.g.*, in an inguinal hernia, examine the internal abdominal ring and the sac will always be found as a continuation of the parietal peritoneum.

FIG. 717.—Herniotomy. (*Esmarch and Kowalzig.*)

3. A portion of the sac which is non-adherent to its contents is picked up by forceps and cautiously opened with knife or scissors. The first opening is made exceedingly small and is cautiously enlarged until the finger can be introduced and discover the condition of the contents, after which the sac is widely opened.

4. Examination in cases of irreducible and strangulated herniæ almost always shows stricture of the neck by firm surrounding tissues. *Division of stricture:* (A) The classical method is to introduce the finger-nail of the left fore-finger into the stricture, the back of the finger being against the hernia, keeping it out of the way (Fig. 717). A hernia knife is laid flat

*The layers spoken of are not layers described by anatomists; such are rarely recognized and never sought, but are such thin sheets of tissue as happen to be picked up by the forceps.

on the palm of the finger and pushed along until its blunt nose has got beyond the constricting band. The edge of the knife is now turned and pressed against the stricture in such a way as to make a number of small nicks instead of any definite cut. No sawing motion should be given to the knife and its edge should always be blunt. In inguinal hernia if these precautions are adhered to, it makes little difference whether one cuts upwards and outwards, upwards and inwards, or only generally upwards, since such a knife, so used, would be extremely unlikely to injure any vessel. Should any vessel be divided and bleeding occur, it is easy to enlarge the wound and ligate the bleeding point. A herniotomy knife, while convenient, is not necessary—its work can be done by a pair of blunt-pointed scissors. (B) Most surgeons now advocate the division of the constricting tissues from without inwards, exactly as the canal is opened during a radical operation. This is the easiest, safest and best method to follow.

FIG. 718.—Chain ligatures applied to omentum.

FIG. 719.—Repair gangrenous gut. (*Guibé.*)

5. *Contents of the Sac.*—If the contents consist of healthy gut or healthy non-adherent or non-redundant omentum, they are to be reduced at once. If adhesions are present, they must be gently torn through or divided between ligatures. Sometimes adhesion between gut and sac is so firm that a thin portion of sac has to be cut away and left attached to the gut. If the omentum is redundant, inflamed or much lacerated from the division of adhesions most of it should be removed. This is done by placing a chain of ligatures across it (Fig. 718) and cutting away the peripheral portion at a distance of *at least* one inch from the ligatures.

Remove as little omentum as possible; omentum is most valuable.

Should the gut be gangrenous, it may be dealt with in several ways:

(*a*) Only a small spot on the free surface of the gut is gangrenous, the rest of the gut is healthy. Invaginate the gangrenous patch by a few Lembert sutures (Fig. 719). Examine to see if the invagination produces too much narrowing of the gut.

If the gangrene affects all or nearly all the circumference of the gut, but affects little of its long axis, use Summer's operation (p. 451).

Gangrene is extensive. Pull down healthy gut from beyond the stric- caused by the constricting abdominal opening (Fig. 720). Doubly clamp he afferent and efferent loops of gut. If an end-to-end union is to be

FIG. 720.—Examination of constricted gut. (*Veau.*)

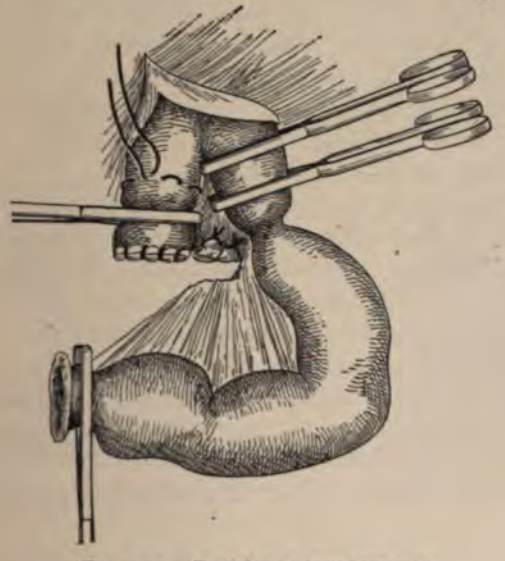


FIG. 721.—Excision gangrenous gut.

the clamps nearest the body must be protected with rubber tubing and *not* crush. If a lateral anastomosis is contemplated, crushing forceps are Divide between the forceps, Fig. 721. Ligate and divide the mesentery. ve the excised gut and mesentery.

With through-and-through catgut sutures, close the ends of both segments of gut protruding from the clamps. Insert a purse-string suture (Fig. 721) on the body side of each clamp. Remove the clamps. Invaginate the ends of the guts, tighten and tie the purse-string sutures. Unite the afferent and efferent loops of gut by lateral anastomosis. (Instead of lateral anastomosis, end-to-end or end-to-side anastomosis may be practised.) If there is doubt as to the viability of the gut or as to the cleanliness of the field of operation fix the united segments of gut near the wound in the parietes by means of a well-placed cigarette or oiled-silk drain.

(*c*) The general condition of the patient renders a complete operation hazardous. Excise the gangrenous segment of gut. Unite the open ends of the healthy gut to the wound, thus providing an artificial anus which may be closed subsequently. This is probably the safest plan for inexperienced surgeons to adopt.

(*d*) The general condition of the patient is poor; the temperature is about normal or even subnormal; the pulse is 120 or more; the abdomen is tense and distended. Relieve the constriction, pull down healthy gut and fix it to the wound, the diseased segment being placed outside the belly wall. Incise the gut to obtain intestinal drainage. Do not remove any tissue. Drain the whole wound freely and endeavor to keep the patient alive by suitable food and stimulants.

(*e*) In strangulated femoral hernia it is wise to recognize the fact that the small size of the femoral canal hinders or prevents the proper treatment of the gut. One, therefore, opens the abdomen immediately above Poupart's ligament; protects the belly cavity with pads; reduces the hernia (working from the abdominal side); excises the gangrenous segment; repairs the bowel; provides drainage from below and closes the abdominal wound.

Unless contraindicated by the weak state of the patient or by the necessity of deep drainage, herniotomy ought always to be followed by an effort after radical cure. (*Vide* "Special Operations.")

Retrograde Strangulation of Intestine.—When operating for strangulated hernia remember that two portions of a loop of intestine may protrude into the sac while an intermediary portion of the same loop may remain in the abdomen (Fig. 727). When this is the case it is quite possible for the blood-vessels of the intermediary portion to be caught and obstructed in the hernial ring, thus causing gangrene of the intra-abdominal loop of gut while the two portions actually in the hernia remain unaffected. In two cases (Lorenz) the strangulation was due not to inclusion in the ring of the affected, but to acute flexion of the vessels caused by the dragging on them of the two herniated segments of intestine. Of course the intra-abdominal strangulation demands laparotomy.

SLIDING HERNIA

Sliding Hernia.—When large intestine is present in the hernia that part of the parietal peritoneum to which it is attached (with or without meson) may slide down and form part of the sac. This must be remembered when a portion

large intestine *appears to be* adherent to the sac. Figs. 722, 723, 724, 725, 726, explain sufficiently how the sac may be used to reconstitute the meson and protect the intestinal blood-supply.

Bull and Coley have had relapses in one out of eight cases of sliding hernia operated on by them. Fiaschi ("Australasian Med. Gaz.," Nov. 20, 1907)

FIG. 722.

FIG. 723.—Reconstruction of meson.

FIGS. 722 AND 723.—Sliding hernia. (*Guibé.*)

FIG. 724.—Meson reconstructed.

FIG. 725.

FIGS. 724 AND 725.—Sliding hernia. (*Guibé.*)

FIG. 726.—Sliding hernia, meson reconstructed. (*Guibé.*)

FIG. 727.—Retrograde strangulation.

had considerable experience with sliding hernia and considers relapse to due to "the vicious habit of sliding down acquired by that portion of intes- which formed the sliding hernia."

To counteract the above tendency he supplements the ordinary operation the hernia by anchoring the offending portion of the colon to the belly-wall opexy) through a muscle-splitting (gridiron) incision.

FEMORAL HERNIA

Bassini's Operation.—*Step* 1.—Make an incision 3 inches long, parallel to and below Poupart's ligament (Fig. 728). The center of this incision corresponds to the centre of the hernial swelling. Divide the tissues layer by layer between forceps until the sac is reached. The superficial fascia may be surprisingly thick and fatty.

Step 2.—By blunt dissection free the sac from its surroundings.

Step 3.—Open the sac and reduce its contents. (For treatment of complications see page 592.)

Step 4.—(A) Bassini, having separated the sac from its surroundings up to its junction with the parietal peritoneum (of which it is a mere process), transfixes and ligates it at this point and cuts away the peripheral portion. Many surgeons close the external wound and terminate the operation at this point.

(B) Macewen, having separated all the sac from its surrounding, pushes his finger through the femoral opening outside the sac and separates the parietal peritoneum from the parietes for a distance of ¾ inch above the opening. He then treats the sac exactly as in his operation for inguinal hernia, making it into an intra-abdominal pad. (See page 604.)

Step 5.—Make a careful survey as to the position of Gimbernat's ligament, Poupart's ligament, the plica falciformis, and the pectineal fascia. Retract the plica falciformis upwards and outwards. With a full curved needle introduce the suture A-A (Fig. 729) through the inferior and posterior part of Poupart's ligament and the pectineal fascia close to the pubic spine. About ¼ inch external to A-A introduce the suture B-B. In the same way the suture C is introduced and ought to lie about ½ inch internal to the femoral vein. The sutures A, B, and C are left for the present without being tied.

Step 6.—The plica falciformis is stitched to that portion of the pectineal fascia which

FIG. 728.—Incision femoral hernia.

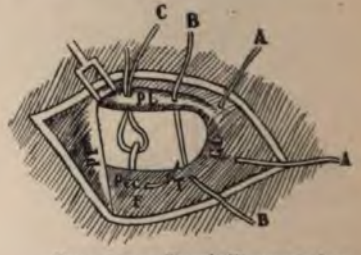


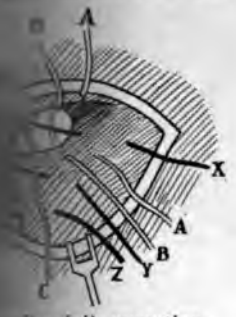
FIG. 729.—Bassini's operation.

normally forms the posterior wall of the femoral funnel. The insertion of these stitches is shown in Fig. 730 (X-X, Y-Y, Z-Z).

Step 7.—The sutures A-A, B-B, C-C, are tied. This approximates Poupart's ligament to the fascia covering the horizontal ramus of the pubis. The sutures X-X, Y-Y, Z-Z are tied. This slides the plica falciformis inwards to its normal position or to an exaggeration of its normal position, and completes the closure

long saphenous vein is left to dip unmolested under the in-
ca falciformis. (N. B.—Sutures A-A, B-B, C-C close the ab-
the femoral canal. Sutures X-X, Y-Y, Z-Z close the canal

of the skin-wound.



lassini's operation.

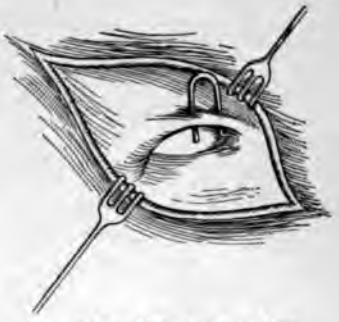


FIG. 731.—Roux's operation.

ion.—The hernia is exposed and its sac ligated and excised
peration. The peculiar feature of the operation is the method
noral canal, as follows: Pass a metal staple obliquely through
nt over the crural canal to the inside of the femoral vessels,
ng the vein (Fig. 731). Gently hammer the points of the
pubis. The staple or nail must not be inserted too tightly lest

FIG. 732.—(*Baldwin.*)

FIG. 733.—(*Baldwin.*)

's ligament be injured. J. Crawford Renton reports that Roux has
ully used this method in 60 cases and he himself in 10. The superficial
is closed in the usual manner.

tt Baldwin's Operation ("Lancet," July 21, 1906).—*Step* 1.—Expose
y isolate the hernial sac. Reduce the hernia.

2.—Introduce a slightly curved director or dissector into the femoral
front of the sac and with it dissect a path upwards between the parietal

[illegible] end of the direc[illegible]

[illegible] external oblique. Make [illegible]

[illegible] fibres and protrude the director

[illegible] along the director from [illegible] Seize the distal end of the [illegible] director. Pull the sac [illegible] through the tunnel (Fig. 734).

[illegible] to the fundus of the sac. Leave both [illegible] in the external oblique; ligate the neck [illegible] stitch several times through the

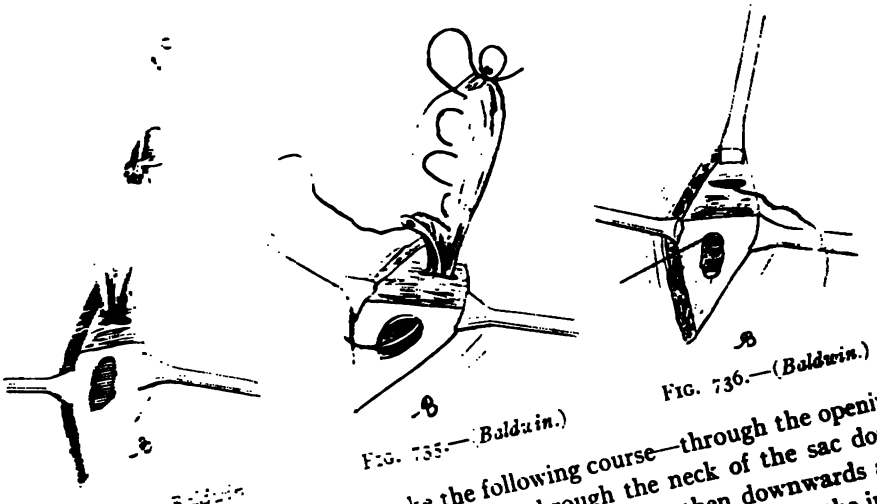


Fig. 734.—Baldwin.

Fig. 735.—(*Baldwin.*)

Fig. 736.—(*Baldwin.*)

sac Fig. 735 and then make it take the following course—through the opening in the aponeurosis of the external oblique, through the neck of the sac down to the horizontal ramus of the pubis which it must hug, then downwards and forwards through the pectineus muscle and fascia to emerge through the inner part of the saphenous opening (Fig. 735).

Step 5.—Pulling on the thread, push the sac back through the opening in the aponeurosis until it is lost to sight. The tucking away of the sac may be aided by the use of a stout probe or a forceps.

The sac now lies curled up behind Poupart's ligament; from it one end of a suture hangs out through the small opening in the aponeurosis; the oth end of the suture passes through the tissues on the deep side of the femo canal (Fig. 736). Tie the two ends of the suture together; this closes femoral canal.

Baldwin's operation seems better suited to the female than to the because of anatomical considerations.

Dujarier's Operation.—("Journal de Chir.," Feb., 1912.)

Step 1.—Open the inguinal canal as in Bassini's operation for ir

hernia. Retract the cord or the round ligament upwards (Fig. 737). Note the deep epigastric vessels and protect them from injury.

Step 2.—Separate the contents of the inguinal canal from the abdominal surface of Poupart's ligament and thus push the parietal peritoneum upwards until the subperitoneal fat is exposed near the femoral canal. Note the position

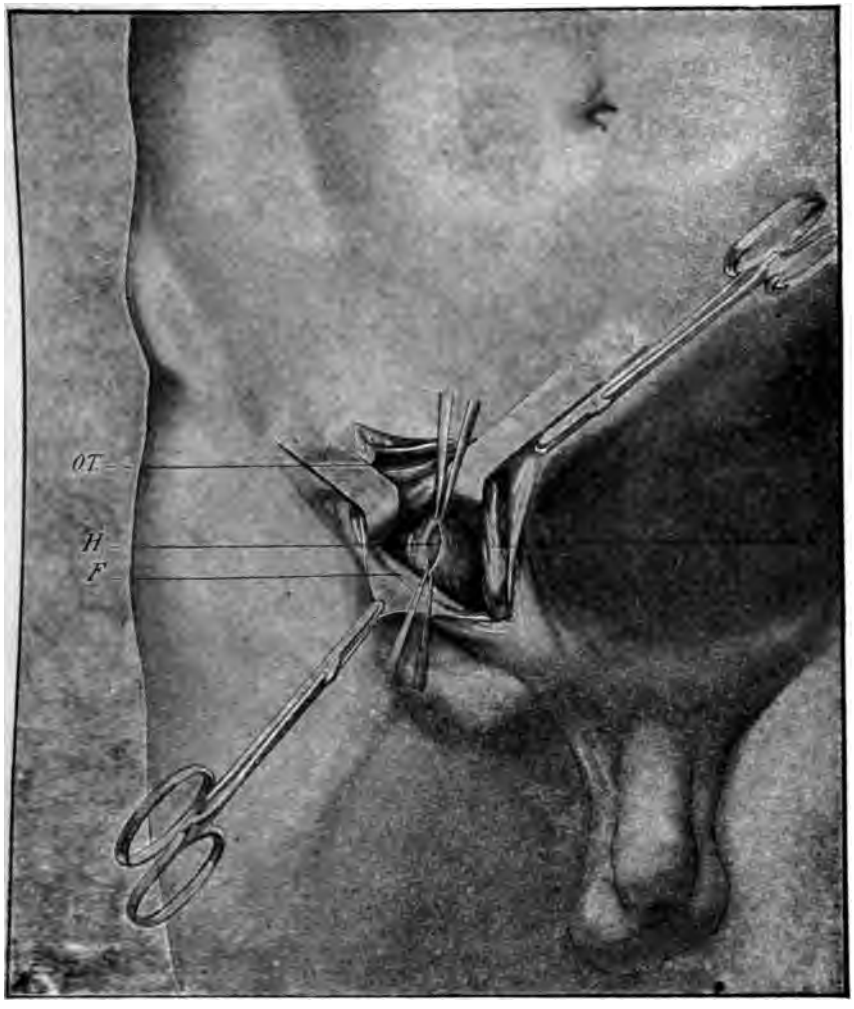


FIG. 737.—(*Dujarier.*)
O.T. Internal oblique and transversalis muscles retracted. H. Incision in peritoneum. C. Cord. F. Poupart's ligament.

of the femoral vein and protect it. Pick up the peritoneum immediately above the femoral canal and incise it. Through the peritoneal wound see if any omentum or viscus enters the hernial sac.

A. If the sac is empty and if there has not been much inflammation it is usually easy, by traction on the peritoneum, to pull the sac out of the femoral canal into the inguinal canal where it may be treated as if it belonged to an in-

peritoneum and Poupart's ligament to a point about ½ inch above Poupart's ligament (Fig. 732). At this point tilt the end of the director forwards so that it can be felt through the aponeurosis of the external oblique. Make a short incision through the aponeurosis, parallel to its fibres and protrude the director through the opening.

Step 3.—Pass a forceps (sinus forceps or hæmostat) along the director from above downwards (Fig. 733). Remove the director. Seize the distal end of the sac with the forceps and pull it through the tunnel (Fig. 734). Pull the sac as far as possible through the opening in the external oblique; ligate the neck of the sac.

Step 4.—Fix a stout stitch of catgut to the fundus of the sac. Leave both ends of the stitch long. Pass one end of the stitch several times through the

FIG. 734.—(*Baldwin.*)

FIG. 735.—(*Baldwin.*)

FIG. 736.—(*Baldwin.*)

sac (Fig. 735) and then make it take the following course—through the opening in the aponeurosis of the external oblique, through the neck of the sac down to the horizontal ramus of the pubis which it must hug, then downwards and forwards through the pectineus muscle and fascia to emerge through the inner part of the saphenous opening (Fig. 735).

Step 5.—Pulling on the thread, push the sac back through the opening in the aponeurosis until it is lost to sight. The tucking away of the sac may be aided by the use of a stout probe or a forceps.

The sac now lies curled up behind Poupart's ligament; from it one end of a suture hangs out through the small opening in the aponeurosis; the other end of the suture passes through the tissues on the deep side of the femoral canal (Fig. 736). Tie the two ends of the suture together; this closes the femoral canal.

Baldwin's operation seems better suited to the female than to the male because of anatomical considerations.

Dujarier's Operation.—("Journal de Chir.," Feb., 1912.)

Step 1.—Open the inguinal canal as in Bassini's operation for inguinal

. Retract the cord or the round ligament upwards (Fig. 737). Note
ep epigastric vessels and protect them from injury.
p 2.—Separate the contents of the inguinal canal from the abdominal
e of Poupart's ligament and thus push the parietal peritoneum upwards
he subperitoneal fat is exposed near the femoral canal. Note the position

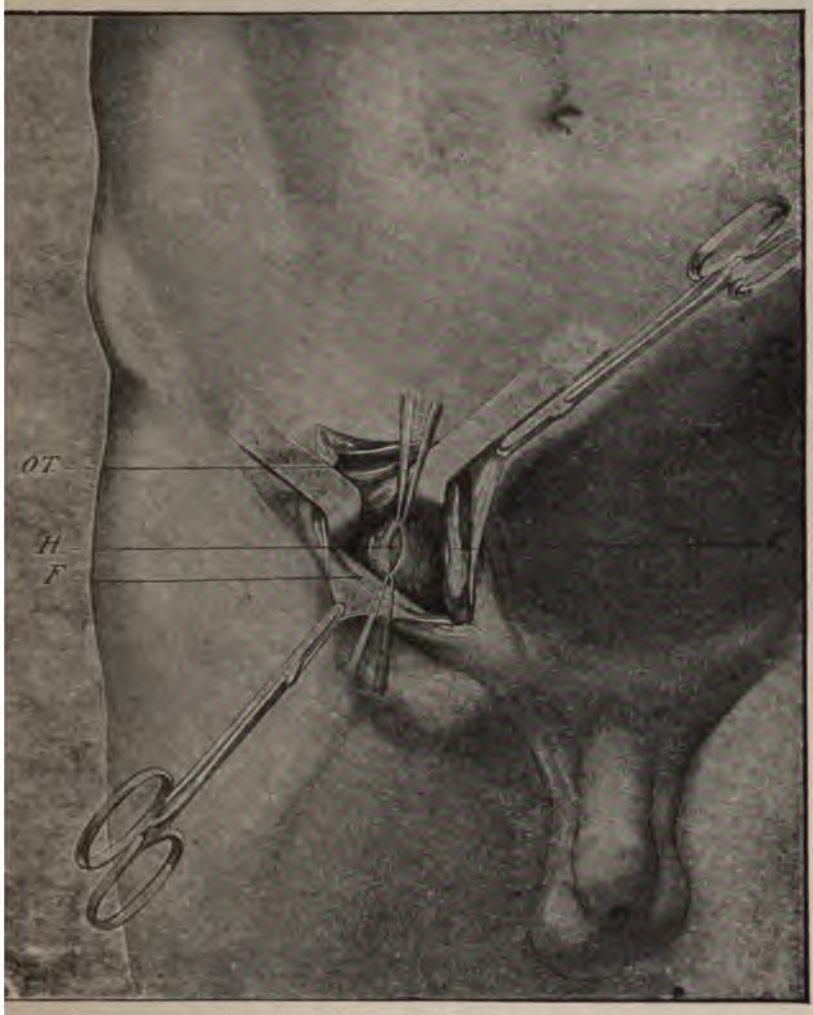


FIG. 737.—(*Dujarier.*)
ternal oblique and transversalis muscles retracted. H. Incision in peritoneum. C. Cord. F. Poupart's ligament.

femoral vein and protect it. Pick up the peritoneum immediately above
moral canal and incise it. Through the peritoneal wound see if any
um or viscus enters the hernial sac.

If the sac is empty and if there has not been much inflammation it is
y easy, by traction on the peritoneum, to pull the sac out of the femoral
into the inguinal canal where it may be treated as if it belonged to an in-

guinal hernia (Fig. 738). Sometimes reduction of the sac as above is impossible. If the difficulty is due to narrowness of the fibrous ring constituting the femoral canal this is easily overcome by cutting the inner edge of the ring, *i.e.*, Gimbernat's ligament.

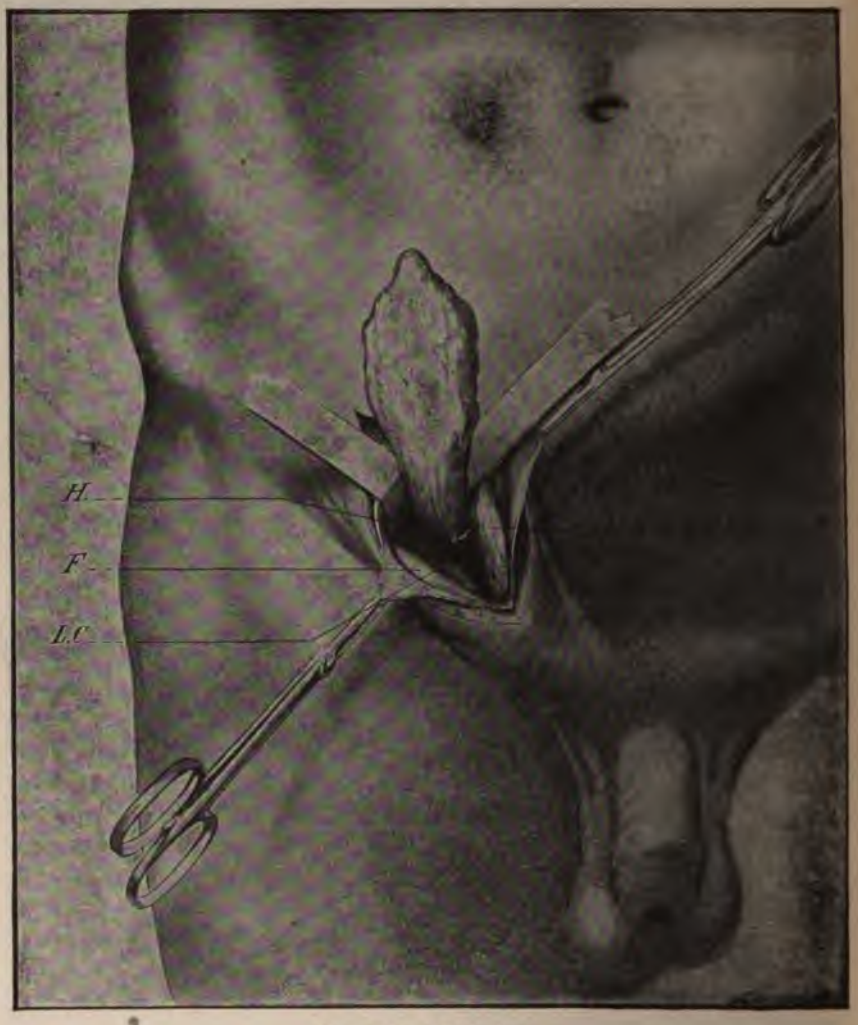


FIG. 738.—(*Dujarier.*)
F. Poupart's ligament. L.C. Cooper's ligament. H. Neck of sac ligated.

If the difficulty in reduction is due to adhesion of the sac to the tissues of Scarpa's triangle, dissect the sac free from these adhesions or if this is too difficult, divide the sac as close as possible to the adhesions leaving the adherent portion of the sac buried in Scarpa's triangle and treating the mobilized sac *secundum artem.*

B. If the sac has contents which are reducible, reduce them and treat the sac as in *A*.

If the contents are not reducible or are strangulated treat them according to the rules laid down on page 592. Dislocate the sac into the inguinal canal.

Step 3.—By traction on the sac try to pull forwards as much peritoneum as possible from above the neck of the sac. Note that the bladder is liable to be dragged into the wound. Ligate the sac as high up as possible (Fig. 738) and cut it away distal to the ligature.

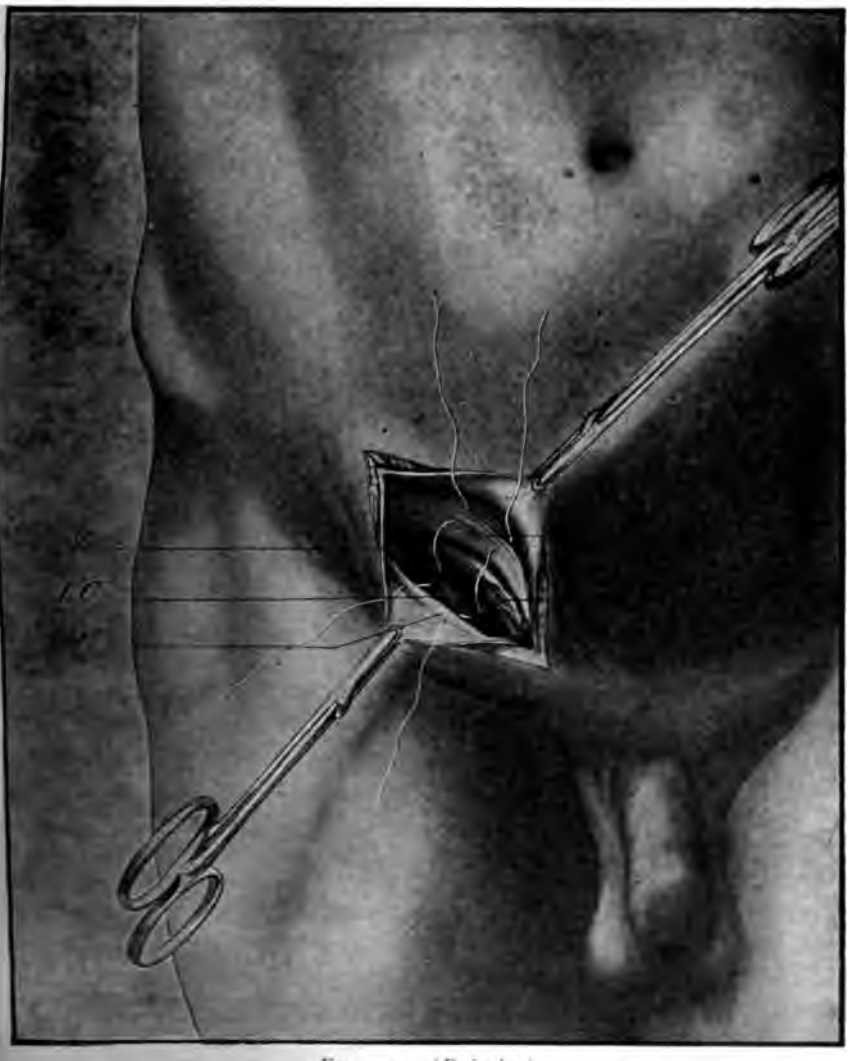


FIG. 739.—(*Dujarier.*)

LC. Cooper's ligament. F. Poupart's ligament. O.T. Internal oblique and transversalis. C. Cord.

Step 4.—Closure of the femoral canal. Insert two or more sutures through the fascia covering the horizontal ramus of the pubes just internal to the femoral vein (Fig. 739). Pass the lower end of each of these sutures through the deep part of Poupart's ligament and the upper end through the internal oblique and transversalis. The spermatic cord lies behind these sutures. When

these sutures are tied the femoral canal and the deep part of the inguinal canal are closed. Reich (Beitr. z. klin. chir., lxxiii, 110) closes the inguinal by suturing the internal oblique and transversalis to Cooper's ligament and the pubic periosteum *without* including Poupart's ligament. Thus the cord lies in front of the sutures.

Step 5.—Suture the wound in the external oblique. Suture the skin.

Seelig and Tuholske (Surg., Gyn. and Obst., xviii, page 58) describe an operation almost the same as Dujarier's. One of their illustrations (Fig. 740) shows the relations of the sac most admirably.

FIG. 740.—(*Seelig and Tuholske, Surg., Gyn., and Obst.*)

Femoral Hernia.—Chaput (Rev. de Gyn. et Chir. Abdom., Nov., 1915) finds that ordinary suture is insufficient in femoral hernia when the opening is large. He therefore plugs the opening with a mass of fat. In subjects over 35 or 40 years of age non-pedunculated implants of fat are very subject to aseptic necroses and absorption hence a pedunculated flap is preferable. Chaput operates as follows:

Step 1.—Open the inguinal canal; mobilize and remove the hernial sac as in Dujarier's operation (p. 598).

Step 2.—With a scalpel trace out a rectangular flap, 10 cm. long, two fingers-breadth wide, with its base at the pubis and its inner border corresponding

to the median line. Remove all the skin in this flap without encroaching on the subcutaneous fat.

Step 3.—Along the lines of the original incision penetrate through the fat to the aponeurosis and elevate a flap of fat with its pedicle below. Make a cut 2 cm. long through the middle of the distal end of the flap.

Step 4.—About 3 cm. from the middle line make a 4 cm. vertical incision through the rectus muscle down to, but not through the peritoneum. Separate the peritoneum from the parietes outward until the inguinal canal and femoral ring are reached. Pull the end of the fat-flap through the tunnel thus formed and suture the posterior half of the distal end of the split fat-flap to Cooper's ligament behind the femoral vein and the anterior half of the flap to Poupart's ligament in front of and external to the vein.

Step 5.—Close the inguinal canal as in Dujarier's operation. In closing the wound in the rectus through which the fat-flap passes insert one thread of catgut through the adjacent borders of the muscle and the upper edge of the flap. Insert a similar suture below the flap.

Step 6.—Mobilize the skin around the vertical wound and close it.

The above closely follows Chaput's description but the writer fails to see any excuse for excising the skin. A vertical incision through the skin ought to give plenty opportunity to form an efficient flap of fat.

RADICAL CURE OF INGUINAL HERNIA

The older operations for the radical cure of inguinal hernia were faulty and unsuccessful because they were based on the idea that the hernia escaped from the abdomen through a *ring*, and that if the *edges of the ring* were brought together, a cure would be obtained. The scar left by such edge-to-edge closure of the ring can never offer any great opposition to recurrence of the hernia. All the good modern operations are based on the idea that the hernia has originally passed through a more or less oblique canal, which it has converted into a ring-like opening, and that to effect a cure it is necessary to reverse the process and convert the ring into an oblique canal—narrower and more resistant to abdominal pressure than the original canal had been. All operations which carry out the above principle are successful in effecting cures.

Macewen's Operation.—1. Make an oblique incision about 3 inches in length over the external abdominal ring. Practically a good rule is to begin the cut 1 inch above and to the outer side of the upper limit of the hernial swelling and continue the incision downwards and inwards over the hernial neck. Expose the upper part of the sac of the hernia.

2. By blunt dissection free the sac from its surroundings and from the spermatic cord, which lies posteriorly. This must be done thoroughly.

3. Reduce the contents of the sac and then open and inspect it. It is often necessary to open the sac before the hernia can or ought to be reduced. (For treatment of complications see page 592.)

4. Pass the finger *outside* the sac through the opening in the parietes and separate the peritoneum (of which the sac is a mere continuation) from the parietes for a space of ¾ inch on every side of the opening (Fig. 741).

5. Should the sac be too voluminous, cut off its distal end, which may be removed or left in the scrotum. Every time it is necessary to make an incision in the sac the position of the cord should be ascertained.

6. A stitch of chromicized catgut is taken through the distal extremity of the sac, which is now hanging loosely through the abdominal wall (Fig. 742),

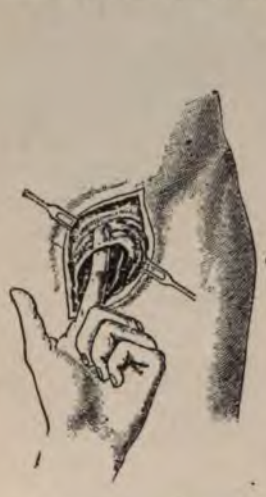


FIG. 741.—Macewen's operation. (*Esmarch and Kowalzig.*)

FIG. 742.—Treatment of sac.

FIG. 743.—Macewen's operation.

and is there tied. The long end of the suture is passed three or four times from side to side through the sac, so that when pulled upon it throws the sac into folds. The loose end of the thread is threaded on a Macewen hernia needle. The needle, guided by the finger, is passed up *external* to the sac through the abdominal opening, and thrust outwards through the whole thickness of the parietes (with the exception of peritoneum and skin) (Fig. 742). If the thread is

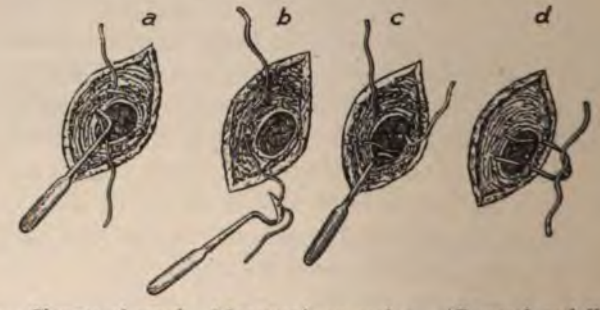


FIG. 744.—Closure of canal. Macewen's operation. (*Esmarch and Kowalzig.*)

now pulled, the sac will be reduced into the belly cavity (external to the peritoneum), and will form a firm, puckered-up pad lying between the peritoneum and the parietes (Fig. 743). The end of the thread is caught by a hemostat and temporarily thrown aside.

7. A Macewen hernia needle is passed through the conjoined tendon from without inwards, and its point, guided by the finger in the abdominal opening,

is carried upwards for about ¾ of an inch and once more passed through the conjoined tendon, this time from within outwards (Fig. 744 *a* and *b*). By this means a strong chromicized catgut thread is placed in position through the inner wall of the ring.

8. The lower end of the suture is now threaded on an appropriate needle and passed through Poupart's ligament from within outwards a short distance above the spermatic cord (Fig. 744 *c*). The upper end of the suture is passed from within outwards through the aponeurosis of the external oblique. We now have a single thread which takes the course seen in Fig. 744 *d*. If one pulls upon the ends of the suture, the tissues external and inferior to the opening (viz., Poupart's ligament and the aponeurosis of the external oblique) must slide over those internal and superior (viz., the conjoined tendon), and when the suture is firmly tied, the obliquity of the inguinal canal is restored. The anterior surface of the conjoined tendon is in apposition with the posterior surface of Poupart's ligament. Before the suture is definitely tied the spermatic cord is examined lest too much pressure be exerted on it.

FIG. 745.—Bassini's operation.

9. The end of the suture used for puckering the sac is now pulled tight and fixed in the belly-wall subcutaneously.

10. The skin-wound is closed.

Macewen makes use of special handled needles, but these are not really necessary. The author has frequently used common full-curved needles grasped in a needle-holder and found them absolutely satisfactory.

Bassini's Operation.—1. An incision is made parallel to and ½ inch above Poupart's ligament. It begins external to the region of the internal abdominal ring and ends internal to the external ring.

2. A firm aponeurotic sheet (aponeurosis of external oblique) covering the hernia is exposed and divided in the direction of the wound with scissors or on a director (Fig. 745). Thus are formed a superior and inferior aponeurotic flap. The superior flap is separated from the subjacent tissues for a distance of 1 or 1½ inches.

3. The hernial sac now lies exposed from its peritoneal origin to the point where it disappears into the scrotum, and is recognized according to the rules

described on page 591. With blunt dissection the sac is separated from its surroundings and from the spermatic cord. This must be done thoroughly and carefully. The sac should be opened and its contents reduced or treated as described on page 592.

4. Downward traction being exerted on the sac, its neck is transfixed and ligated as high up as possible, and the distal portion cut off. The stump should retract into the belly cavity and be lost to sight. Sometimes the neck of the sac is so bulky or of such a shape that ligation is impossible. In these cases the neck of the sac is sewed up and the distal portion removed. By whatever method the neck is closed and divided, special attention ought to be paid to the position of the spermatic cord, as this important structure has frequently been injured. Separation of the sac from its surroundings has freshened all the tissues so that if placed in apposition they will unite. It is not always necessary to excise the distal portion of the sac. After isolation, ligation and division of the neck the remainder of the sac may be permitted to drop into the scrotum. The author has occasionally seen this procedure followed by the development of a hydrocele, but if the cord and testicle are pulled out of the scrotum and the remnants of the sac turned outside-in over them no hydrocele can develop and considerable dissection may be avoided. (See Eversion of Hydrocele Sac, Jaboulay's Operation.)

FIG. 746. FIG. 747. FIG. 748.

FIGS. 746, 747 AND 748.—Bassini's operation.

5. The spermatic cord is raised from its bed and held out of the way by a blunt hook. Review of the wound now shows that its upper edge consists of three layers; (A) A deep thick layer, marked muscular flap (Fig. 746). (Internal oblique and transversalis muscles, transversalis fascia, and external margin of the rectus.) (B) Superior aponeurotic flap. (Aponeurosis of external oblique.) (C) The skin. The lower edge of the wound consists of the deep layer of Poupart's ligament on which the spermatic cord normally lies, the inferior aponeurotic flap, and the skin.

6. A suture is now passed through the muscular flap (Figs. 746, 747) close to the exit of the cord from the abdomen, and unites it to the deeper layer of Poupart's ligament. This suture must be so placed as to close the wound beside the cord, but yet not interfere with its circulation. Some surgeons place a suture external to the cord at the point marked x, Fig. 747. This is important. The whole edge of the muscular flap (Figs. 746, 747) is stitched to the deep layer of Poupart's ligament.

7. The cord is now laid on the top of the line of suture and the superior and inferior aponeurotic flaps united over it (Fig. 748).

8. The skin-wound is closed.

...e's Operation (Surg., Gyn. and Obst., Nov., 1919) has much to ...mmend it, as it facilitates the exposure and safe mobilization of the sac ...l ensures good closure of the internal ring.

Step 1.—Expose and split the aponeurosis of the external oblique as in ...assini's method. Along a line about 1 inch above their lower margin, pene...rate the internal oblique and transversalis muscles by separation of their muscle bundles and open the peritoneum *above* the neck of the sac. (If the muscles are attenuated they may be retracted upwards and thus the proper place for opening the peritoneum may be reached without muscle splitting.)

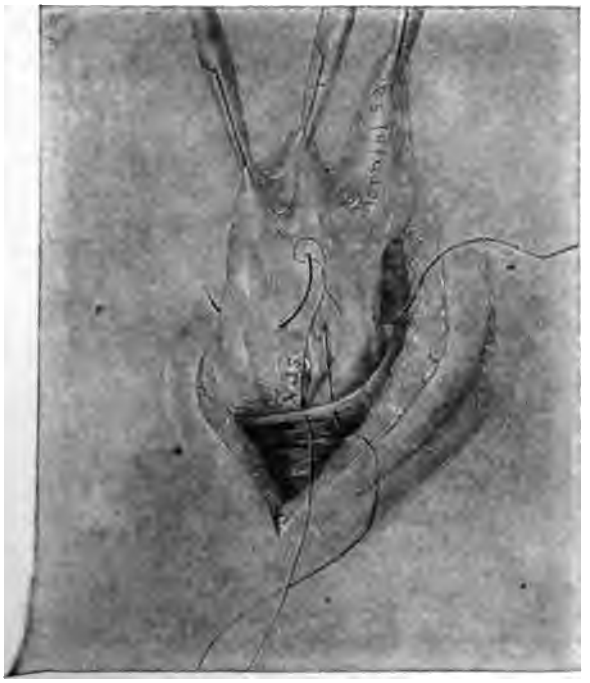


FIG. 749.—La Roque's Operation. (*Surg. Gyn. & Obst.*)

...Treat the hernial contents from the abdominal side. Pass a ...he sac and thus guided, separate the sac from its surroundings. ...ith a hemostat grasp the apex of the sac and inverting the sac ...th any redundant peritoneum, out through the peritoneal open... the eye pass sutures through the redundant peritoneum well ...of the sac thus closing the opening into the sac. Let each of ...se a bite in the upper edge of the original peritoneal wound. ...ess of sac. Close the split in the muscles. ...the inguinal canal in the usual fashion.

(Brit. Med. J. Oct. 27, 1917).

...above the center of Poupart's ligament make a one-inch ...ment and expose the aponeurosis of the external ...matic cord. Split the aponeurosis for about one-

2. Expose the cremasteric and fascial coverings of the cord and pul through the wound. Separate the cremasteric fibres and incise the spe fascia. This exposes the sac.

3. Pick up the sac with two fine hemostats. Open the sac betwe forceps. Apply two more forceps to the edges of the opening in the expose the interior. The interior of the sac shows two openings one l into the abdomen the other into the scrotum. These openings are sep by a ridge of peritoneum (the crista) (Fig. 750). Pick up the crista in two places with forceps. Complete the transverse division of the sac to the forceps. By lifting up the forceps the neck of the sac can be separated from its surroundings. Transfix the sac with a needle armed catgut, ligate it and permit it to retract inside the abdominal wall. I transfixion is used the ligature may slip off the sac.

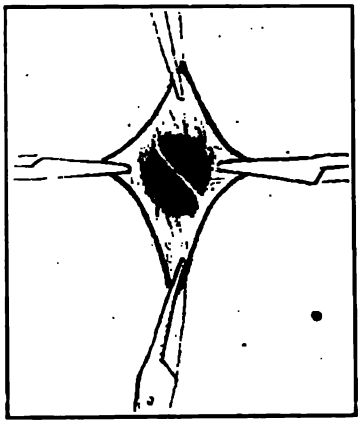


FIG. 750.

4. Suture the skin and the wound in the aponeuros (most surgeons would suture the aponeurosis with cat any material preferred.)

In 90 per cent. of cases this is all that is necessary. ternal ring is very large or the peritoneum is thin the c over the cord and sutured to Poupart's ligament with

Ferguson's Operation.—A. H. Ferguson has not of the internal oblique and transversalis muscles fruitful cause of recurrence after operations for t To expose and correct such deficiency he has dev

Step 1.—Make a semilunar incision, with con in Poupart's ligament 1½ inches below the ant on the conjoined tendon near the pubis (Fig outlined, exposing the aponeurosis of the exte

Step 2.—Cut through the external ab fascia; sep ngitudinal fibres of the directly inal canal, far beyon

e internal oblique, and up under the skin to a point nearly opposite the ior superior spine (Fig. 751). This exposes all the contents of the inguinal , and any deficiency in the origin of the internal oblique and transversalis les is seen.

ep 3.—Attend to the hernial contents and sac in the manner already ibed.

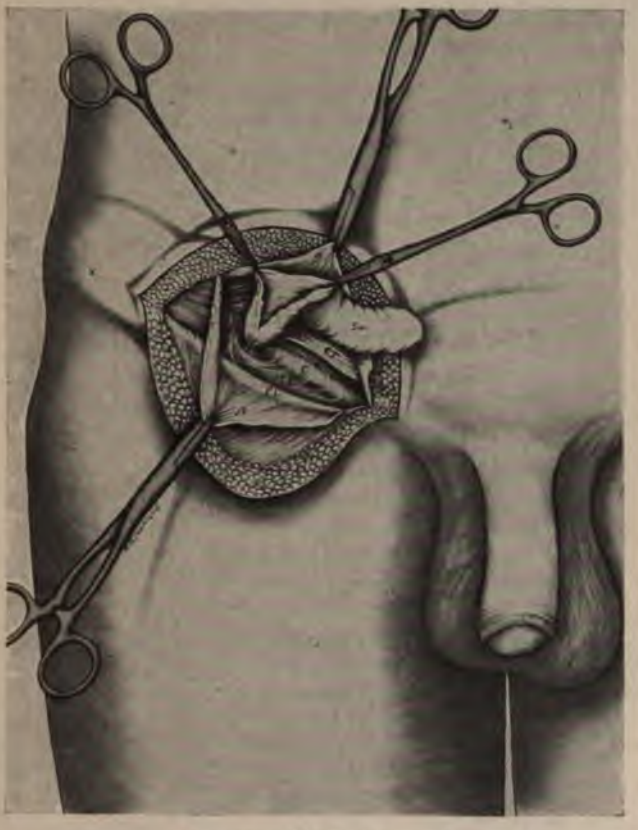


FIG. 751.—(*A. H. Ferguson.*)

tep 4.—Lessen the size of the dilated internal ring by means of a few nes (Fig. 752). Suture the internal oblique and transversalis muscles ne inner aspect of Poupart's ligament and restore their normal origin 753). The line of suture extends fully two-thirds down the ligament. care *not* to split the ligament by grasping with the needle the same longi- nal fibres each time. In this step the Mayos suture the upper edge of wound in the external oblique fascia along with the internal oblique muscle ne inner aspect of Poupart's ligament and then make the lower portion ne fascia (continuous with Poupart's ligament) overlap the line of suture fix it in position by means of a few stitches. Close the wound in the eurosis of the external oblique. Restore the external abdominal ring. ace and suture the semilunar skin-flap.

After-treatment.—Bassini permits his patients to leave their beds
to work after the lapse of two weeks. Macewen believes that no
is firmly healed after such a short time. When it is possible to carry o
following rules, they will be found exceedingly satisfactory:

For a period of three or four weeks after operation, rest in bed.

For a period of six weeks after operation, when the bowels are being m
the patient should be in the recumbent posture so as to avoid strain
wound. The squatting posture with thighs flexed on and supportin
abdomen is as good and more humane.

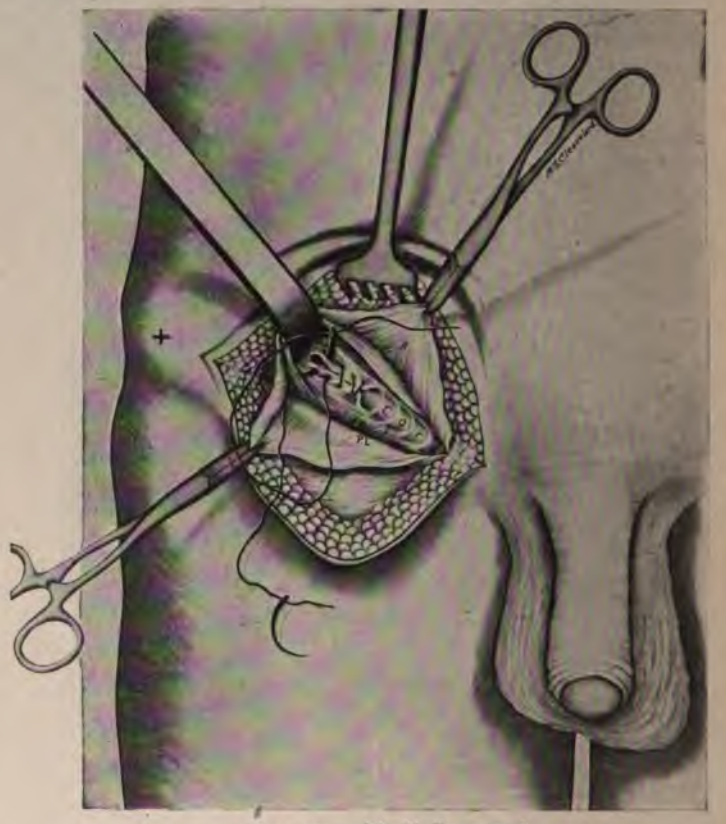


FIG. 752.—(*A. H. Ferguson.*)

For a period of three months after operation there should be no hard
work.

The Johns Hopkins Operation for Hernia.—This operation is the
of the experience and ingenuity of the surgical staff in the Johns H
Hospital. It is based on the original operation of Halsted, modified b
self and Bloodgood. ("Johns Hopkins Bulletin," August, 1903.)

Step 1.—Divide the skin and the aponeurosis of the external obli
in the Bassini operation. Reflect the aponeurotic flaps.

Step 2.—Split the cremaster muscle and fascia along a line a little
the centre of the cord.

Step 3.—Expose clearly the internal oblique muscle beside the canal.

Step 4.—Examine the hernia and the cord. If the veins are large, and this is usually the case, excise them with very great care to avoid even the slightest extravasation of blood into the tissues about the smaller veins and about the vas deferens which they accompany. Do *not* raise the vas deferens from its bed; do not handle or even touch it, if possible, lest thrombosis of its veins occur (Fig. 754). Ligate the veins as high up in the abdomen as possible, pulling them quite firmly just before the ligature (in a needle with

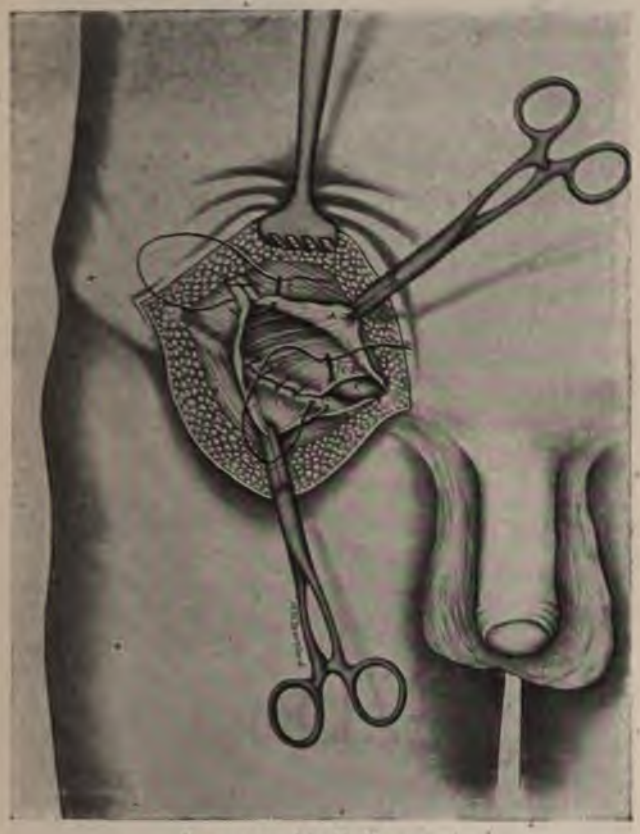


FIG. 753.—(*A. H. Ferguson.*)

he blunt end first) is passed between them. Ligate the lower portions of he veins at a point as high above the testicle as possible, the stump being, f course, outside the external abdominal ring.

Step 5.—Ligate the sac by transfixion or purse-string suture at the highest ossible point. After tying this suture thread its ends on long curved needles nd pass them outwards under the internal oblique muscle to penetrate the nuscle from within outwards at two points about 5 mm. (⅜ inch) apart. Tie he ligatures. This step dislocates the neck of the sac in a manner essentially he same as is recommended by Kocher.

Step 6.—Draw the lower flap of cremaster muscle and fascia up under the

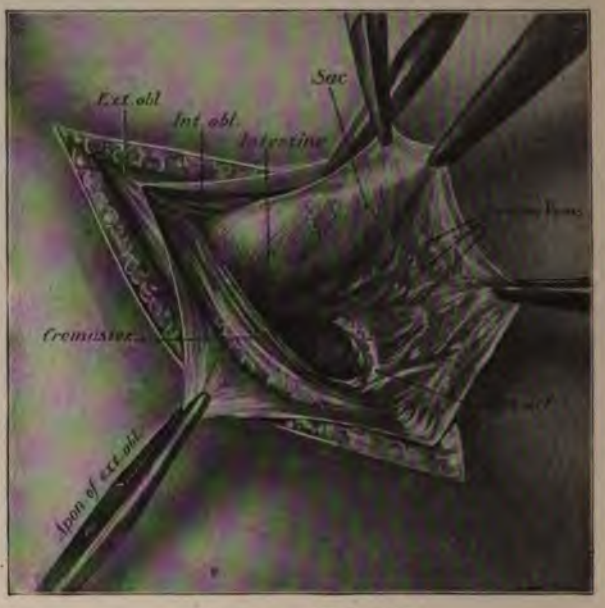


FIG. 754.—(*Halsted.*)

FIG. 755.—(*Halsted.*)

blique muscle, and fix it there by fine sutures which, having engaged ew bundles of the cremaster, perforate the internal oblique, pref- re it is becoming aponeurotic, and are tied on the external surface of (Fig. 755).

FIG. 756.—(*Halsted.*)

FIG. 757.—(*Halsted.*)

—Stitch the internal oblique muscle, mobilized and possibly further y incising the anterior sheath of the rectus muscle (along with its tendon) to Poupart's ligament (Fig. 756). Do this in such a manner wer edge of the internal oblique is tucked under Poupart's ligament.
—Suture the aponeurotic flaps of the external oblique by the An- sted method, which makes them overlap (Figs. 757, 758).
—Close the skin-wound.

Where the hernial opening is very large and the conjoined tendon atrophied a flap of the anterior sheath of the rectus muscle may be reflected outwards and downwards and sutured to the under surface of Poupart's ligament (Fig. 759). This flap of fascia aids in closing the canal by the usual means.

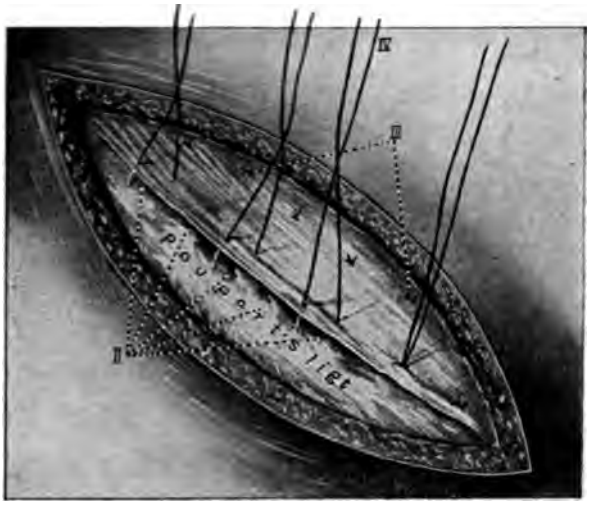


FIG. 758.—(*Halsted.*)

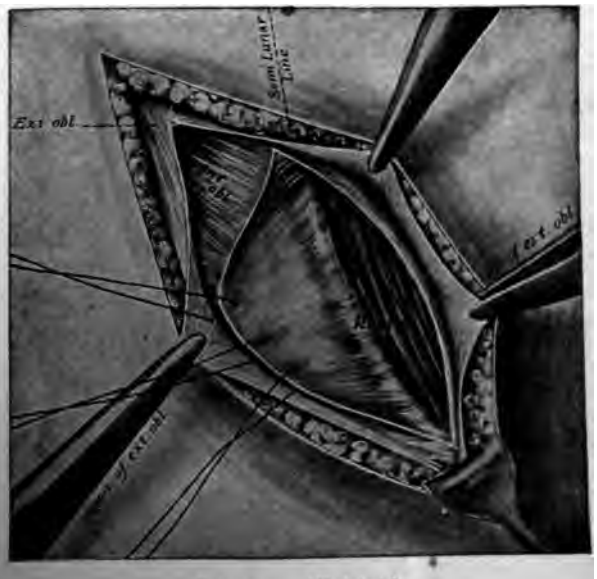


FIG. 759.—(*Halsted.*)

Kirschner ("Archiv für klin. Chir.," xcii, 896) supports the line of s follows: Make an incision through the skin of the thigh and expose su area of fa excise a strip of fascia lata longer than the hernial wo ou about nd one-half inches wide; spread this "free" fascial flap the i closing the inguinal canal and suture it there.

In an inguinal hernia which had recurred after operation by two excellent rgeons, the author adopted Kirschner's method with gratifying results. He s found the free transplantation of fascia of much value for many purposes. Instead of using a flap of rectus sheath to aid in closing the inguinal canal en the conjoined tendon is insufficient, Bloodgood splits the outer margin the rectus sheath from the pubic insertion upwards for 2 inches (5 cm.). e muscle bulges from the cut and is sutured to Poupart's ligament.

When Poupart's ligament has been destroyed or greatly weakened the same rgeon (Annals of Surg., July, 1919, p. 86) has repaired the defect by dividing e Sartorius in the middle of the thigh, isolating it except at its upper attach-nt, placing it over the inguinal canal and suturing it in place.

En résumé.—The special features of the Johns Hopkins methods of operating are:
1. Excision of the veins of the cord and avoidance of injury to the vas deferens.
2. Use of the cremaster muscle and fascia to strengthen the closure.
3. Overlapping of the various structures brought into apposition.
4. Reinforcement of the lower part of the wound when necessary by a flap of rectus fascia, by rectus transplantation.

Inguinal Eventration. Chaput (La Pr. Med., June 19, 1919) has given this me to those inguinal herniæ where not only is the ring very large but where parietes above and external to the ring are thin and weak and in which ordinary operations such as Bassini's are insufficient. Several methods muscle transplantation may be used to give material with which to occlude canal.

Method A. Step 1.—Expose and treat the hernial contents and sac as in the ssini operation.

Step 2.—Continue the incision up to the anterior superior iliac spine. From s point make a cut downwards and inwards along the Sartorius for a distance about four or five inches. Divide the muscle transversely at the lower end he wound and mobilize it (along with the fascia covering it) up to its origin.

Step 3.—Suture the upper end of the lower segment of the muscle to the ghboring fascia.

Step 4.—Insert the mobile muscle flap into the inguinal canal. Suture its tal end to the pubes and its sides to Poupart's ligament and the boundaries the inguinal canal.

Step 5.—Close the wounds.

This operation has been practiced by Bloodgood; Streissler; Salva Mercedé d Chaput.

Objections to the operation are that, (*a*) The Sartorius is sometimes not rge enough to serve, (*b*) along the site from which the muscle was taken a rous tissue cord may form which may cause pain and interference with ex-nsion of the thigh while loss of part of the muscle may weaken flexion (Chaput)

Method B. Step 1.—As in Method *A*.

Step 2.—Extend the primary incision to the anterior superior iliac spine d continue it downwards and backwards to the middle of the trochanter ajor. Freely expose the anterior part of the gluteus medius and from it

fashion a flap with pedicle above. The flap should be about ¾ inch (2 cm.) thick, two finger breadths wide and long enough to easily reach the pubes.

Step 3.—Place the flap in the inguinal canal; suture its free end to the pubes and its sides to the fascias bounding the canal. Remarks—it is always possible to secure enough muscle to form a satisfactory flap except sometimes as regards length, and there is little or no interference with function, but the wound is very large and there is much trauma which naturally favors infection.

Method C.—Chaput (*loc. cit.*) favors this method.

Step 1.—As in preceding methods.

Step 2.—Continue the skin incision upwards and outwards parallel to the iliac crest to a point two finger breadths posterior to the anterior superior spine.

Step. 3.—From a point on the incision one finger breadth posterior to the anterior superior spine make a cut vertically down the thigh for a distance of 6 or 7 inches (15 to 18 cm.), along the course of the tensor vaginæ femoris. Reflect the skin along this incision so as to freely expose the muscle.

Step 4.—Divide the muscle transversely at the lower end of the wound and mobilize it from below up, along with its fascial envelope. Preserve the attachments to the iliac crest.

Step 5.—Suture the free end of the flap to the pubes and its sides to the appropriate structures bounding the inguinal canal.

Diastases or weaknesses of the lower lateral abdominal walls above the inguinal region may be closed by muscular flaps as described above, the free ends of the flaps being sutured to the rectus abdominalis muscles. Sometimes flaps from all three sources may be used, one to supplement the other.

Obturator Hernia.—This hernia is rarely diagnosed before symptoms of strangulation have appeared.

Method A.—Place the patient in the Trendelenburg position. Open the abdomen. Look for the hernia at the site of the obturator foramen which is directly posterior to the femoral canal. Reduce the hernia treating the strangulated gut *secundum artem.* The constricting hernial ring may be nicked backwards to permit reduction. Extirpate the sac or its neck. Close the hernia opening with a few sutures.

Method B.—When obturator hernia is suspected the obturator foramen may be explored through the inguinal canal. E. T. C. Milligan (Brit. Med. Jour. Aug. 2, 1919) operated as follows: Open the inguinal canal as in Bassini's operation. Retract the spermatic cord upwards. Recognize the external iliac vein and the femoral canal. With deep retractors push the peritoneum upwards from the pubic bone until the obturator canal is reached about 1 inch behind the femoral ring. This method is not suitable when strangulation is present.

Umbilical Hernia.—The classical method of operating in cases of umbilical hernia was to make a vertical incision more or less over the center of the swelling, open the sac, free the contents, reducing intestine and excising redundant omentum. Ransohoff has shown that much time is lost and danger to viscera incurred by this method of attack, and has laid down the principle that the incision should always be made into the free abdominal cavity at the neck of the sac.

Modified as above, the classical operation may be described as follows:

Step 1.—Make a vertical incision from a point well above the hernia to a similar point below. When passing the hernia, the incision should be deflected to one side or the other of the umbilicus (Fig. 760).

Step 2.—Through the above incision without opening the sac dissect down to and freely expose the aponeurotic structures *at one side* of the neck of the hernia.

Step 3.—Open the sac at its neck; reduce any extruded gut. Ligate and divide redundant omentum and reduce the omental stump. Place a gauze pad against the opening into the abdomen and excise the hernial sac, the remains of omentum which it may contain, and such redundant skin as may require removal. This excision may be done rapidly, as all danger of injury to gut, etc., has been avoided by its early isolation and reduction.

Step 4.—Close the peritoneal wound by a row of catgut sutures.

Step 5.—By sharp and blunt dissection open the rectus sheath on both sides of the wound and expose the edge of both recti muscles.

Step 6.—Unite the posterior layer of rectus fascia or sheath by sutures. Suture together the rectus muscles. Unite the anterior layer of rectus fascia. Close the skin-wound.

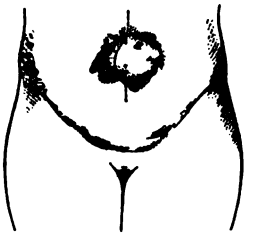


FIG. 760.

The above is a good operation in cases of small hernia; but, as the Mayos have shown, when the hernia is large, and, as is usually the case, the patient is fat, there is a wide separation between the recti and these muscles are themselves atrophied. The classical operation has therefore proved inefficient, in the very cases where success is most to be desired. The Mayos' operation has become *the* recognized procedure. It does not seek to obtain muscular apposition but depends for success on the formation of a strong aponeurotic barrier.

The Mayos' Operation (Figs. 761, 762, 763).—*Step* 1.—Make *transverse* elliptical incisions around the umbilicus and the hernia. Deepen these to the base of the hernial protrusion.

Step 2.—For an inch and a half in all directions from the neck of the sac carefully expose the aponeurotic structures.

Step 3.—Divide, in a circular manner, the fibrous and peritoneal coverings of the hernia at the neck. Expose the hernial contents. If viscera are present, separate the adhesions and reduce. Ligate the contained omentum and remove it with the entire sac of the hernia.

Step 4.—Grasp with forceps and approximate the margins of the ring. In whatever direction overlapping proves easiest lies the proper direction for closure.

Step 5.—Incise the aponeurotic and peritoneal structures of the ring for a distance of one inch or more transversely to each side. Separate the peritoneum from the under surface of the upper of the two flaps thus formed.

Step 6.—Beginning one inch or more above the margin of the upper flap, introduce three or four mattress sutures, the loop firmly grasping the upper margin of the lower flap. Make sufficient traction on these sutures to permit

of closure of the peritoneum with a continuous catgut suture. Tie the mattress sutures, sliding or pulling the entire lower aponeurotic flap into the space between the peritoneum and aponeurosis above.

Step 7.—With catgut, suture the lower edge of the upper aponeurotic flap to the aponeurosis below. Close the superficial wound.

Kelly's modification of the Mayos' operation. ("Annals of Surg.," May, 1910.)

FIG. 761.—Mayo's operation. Umbilical hernia. (*Mayo.*)

Step 1.—Make a curved transverse incision across the hernia from a p slightly external to the right rectus to a point slightly external to the left re muscle. The concavity of the curve is directed upwards. Expose the fa over both recti.

Step 2.—Divide the fascia over both recti and separate it, from the musc upwards and downwards for a distance of 2 or 3 cm. (¾–1⅛ inches) so as form fascial flaps (Fig. 764).

Step 3.—Isolate and open the hernial sac. Treat its contents in the usu fashion.

Step 4.—Close the peritoneal wound with catgut sutures.

Step 5.—"Haul up and sew the free margin of the lower under the upp flap from side to side with four to six interrupted silk sutures, using, if needs b

gut between them. If the transrectal incision is angled a little upwards the overlapping of the recti is well done, there may be little tension; there lways a greatly diminished tension in the overlapping at the ring itself."

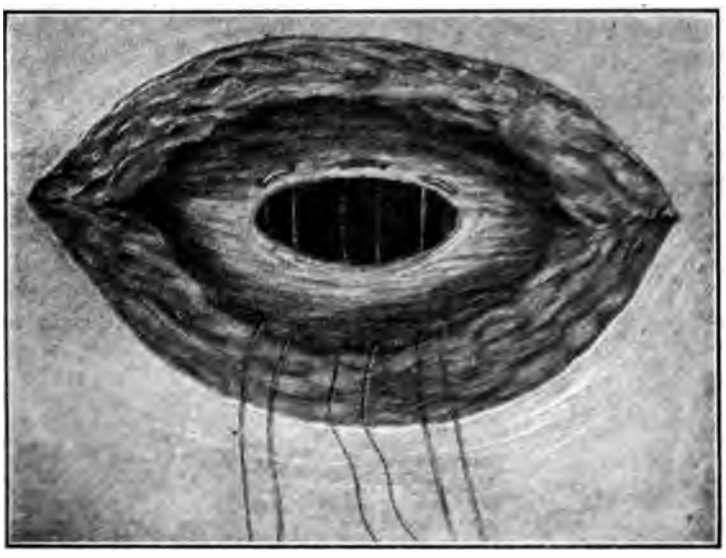


FIG. 762.—Mayo's operation. Umbilical hernia. (*Mayo.*)

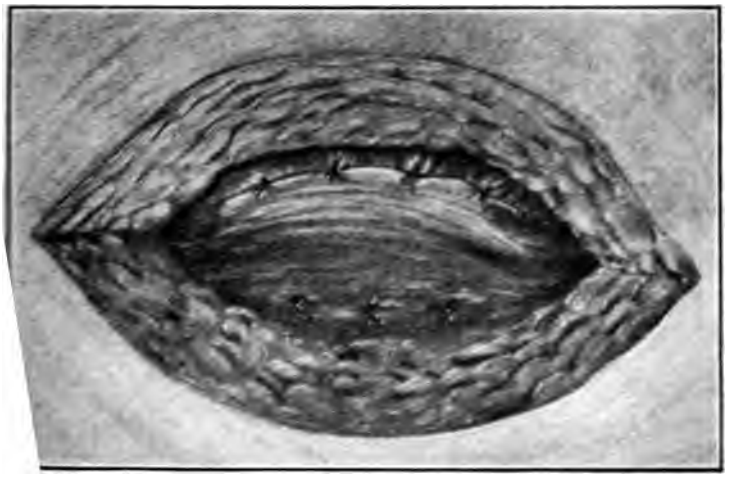


FIG. 763.—Mayo's operation. Umbilical hernia. (*Mayo.*)

ree overhanging margin of the upper flap to the fibrous tissues by a atgut suture.

Close the skin wound.

urge defect in the abdominal wall cannot be closed in the above ome modification thereof, closure has been effected by means of elluloid plate McCosh or of a silver wire meshwork (Phelps,

Willy Meyer, Bartlett). Meyer and A. E. Barker are very urgent in the praise of this method of closure. The meshwork or fence of silver wire seems to be well borne by the tissues and to form the nucleus of a strong mass of connective tissue.

The author has used Bartlett's wire mesh with great satisfaction in a case of hernia resulting from loss of much of the upper end of the right rectus abdominis muscle. Kirschner's plan (p. 614) of the "free" transplantation of a flap of fascia lata may possibly supplant the use of foreign materials.

Ventral herniæ of all varieties are to be treated on the same principles as are advocated for umbilical herniæ. Undoubtedly the best treatment for post-operative ventral herniæ is, to use an Irishism, not to have them. For this

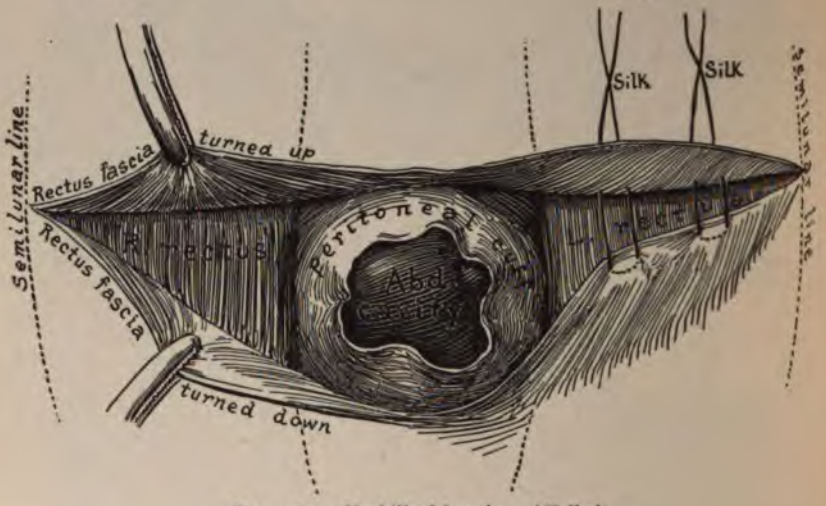


FIG. 764.—Umbilical hernia. (*Kelly.*)

purpose nothing is better than attention to cleanliness, careful closure of the parietes in their anatomic layers, and absolute avoidance of strain until the embryonic tissues necessary for the repair of abdominal wounds have had time to become mature.

Rutherford Morison's Operation.—(1) Make long transverse incisions including the hernia in an ellipse. (2) Expose the rectus sheath above, below and on each side of the hernia. (3) Open the sac and the abdomen through the linea alba below the hernia. (4) Reduce the hernial contents, never cutting away omentum unless absolutely necessary. Cut away sac. (5) With fingers in the abdomen introduce thick catgut mattress sutures through the aponeurosis and rectus muscle on either side but do *not* tighten them. Separate and hold up the mattress sutures so as to expose the peritoneal wound. Suture the peritoneal wound. Infold the aponeurosis by tightening and tying the mattress sutures, making a keel towards the abdominal cavity and bringing broad surfaces of aponeurosis into apposition. Draw surfaces of aponeurosis still more together by thick interrupted catgut sutures above, below and between the mattress sutures. (6) Drain cavity with a tube introduced by small incision

through the *upper* flap. (The skin of the lower flap is often moist and infected.) (7) Apply dressings and support the abdomen with adhesive straps.

Haynes' operation (N. Y. Med. Jour., Vol. cv, o. 107, 1917) is very similar to Rutherford Morison's.

Wullstein's operation for ventral hernia is sufficiently described by Fig. 765. (Zentralblatt für Chir., Sept. 22, 1906, p. 153.)

When a patient with umbilical hernia is atrociously fat it is often wise to operate as follows:

1. Make a transverse curved incision across the abdomen a short distance above the hernia. Make a similar incision, beginning and ending at the same points, below the hernia running in the fold between the pendulous abdominal fat and the supra-pubic region. Incise deeply enough to expose the aponeurosis.

2. Through both incisions separate the fat from the aponeurosis towards the hernia. When the neck of the hernial sac is exposed open it and treat its con-

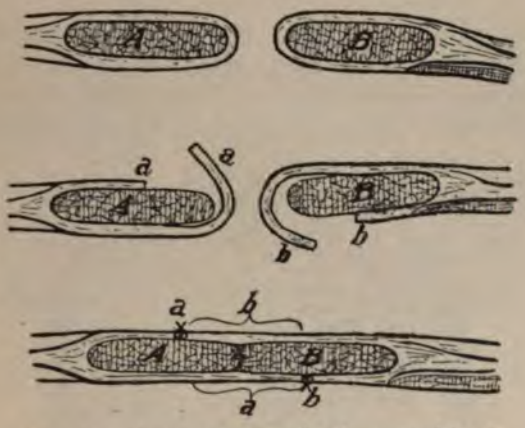


FIG. 765.—Wullstein's operation for ventral hernia.

tents as described in Step 3 of the classical operation (page 617). Remove the skin and fat included between the primary incision. Complete the operation by the Mayo method.

Congenital eventration or evisceration is an extremely fatal deformity. The difficulty in replacing the viscera is due to the fact that the usual infantile "pot belly" is absent, the recti muscles pass straight down from costal margin to pubis; the intestines, though distended with meconium, not having pushed them forwards in the usual fashion.

Charles G. Mixter has operated (personal communication) as follows: If the prolapsed viscera are covered with peritoneum excise this but leave a margin of peritoneum ½ inch wide around the opening at the umbilicus. Enlarge the hernial opening by a transverse incision on each side. Lift up the lower margin of the wound so as to expose the peritoneal surface of the lower anterior abdominal wall. Working from the inside of the abdomen make a transverse incision from the middle line outwards to the flank dividing all the structures of the abdominal wall except the skin and superficial fascia. Make a corresponding

incision at a slightly different level on the opposite side of the lower abdomen. Make similar incisions in the upper part of the abdominal wall. Attend to hemostasis. Empty the bowel by multiple punctures and replace it in the abdomen. Close the wound.

CHAPTER XLVI

RETRO-PERITONEAL, LARGE AND DIAPHRAGMATIC HERNIA

RETRO-PERITONEAL OR INTERNAL HERNIA

Normally the peritoneal cavity is provided with a number of apertures or fossæ which, under ordinary circumstances, are entirely harmless, but which may become dangerous owing to various anomalies of development and to adverse circumstances. The following are the most important of these structures:

1. The foramen of Winslow. In a few cases small intestine has entered the lesser peritoneal sac through this opening. The condition, if found during life, demands that the herniated intestine be reduced into its proper location and that the foramen be lessened in size or obliterated. Probably the trauma

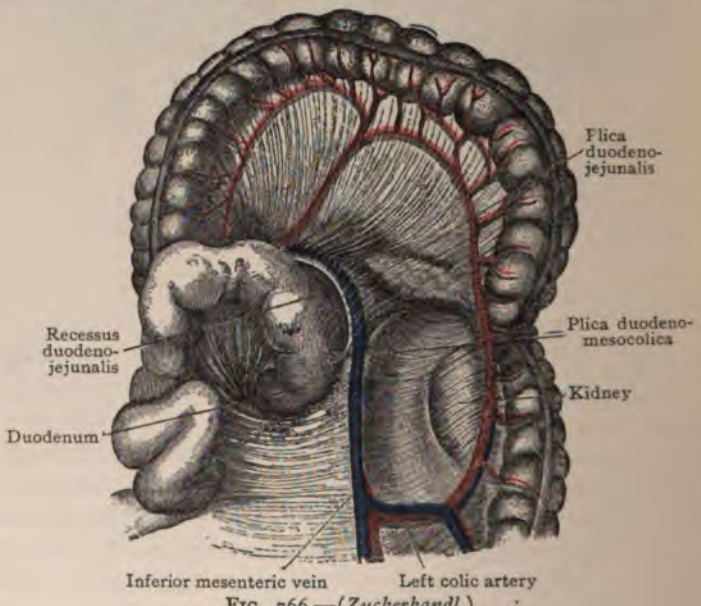


FIG. 766.—(*Zuckerkandl.*)

due to the hernia and its reduction will produce enough plastic peritonitis to effect obliteration; a gauze or cigarette pack introduced into the foramen would act similarly, or one or two catgut sutures may be judiciously introduced.

2. Recessus duodenojejunalis. At the point where the duodenum passes into the jejunum a fold of peritoneum, containing the inferior mesenteric vein, forms a semilunar opening to the left of the origin of the jejunum (Fig. 766). Usually this opening or recess is shallow and not wider than a man's thumb.

Jonnesco and others have described several varieties of recess in this situation, but for our purposes the recognition of its existence and of its proneness to vary, suffices. Intestine may bore its way into the recess described, enlarging the opening and forming a retro-peritoneal hernia (Treitz's hernia). The pouch formed by the herniated gut may stretch to the left under the descending colon and downwards to the pelvis. Upwards the hernia may pass under the root of the transverse mesocolon to a position behind the stomach and spleen. Strangulation is rare. It is commonly supposed that small intestine alone is involved, but Freeman ("Transactions American Surg. Assoc.," 1903) describes a case in which the sac contained the entire small intestine, the cæcum and a portion of the colon, which was strangulated. A. Narath ("Archiv f. klin. Chir.," lxxi, 911) reports a case in which prior to operation the diagnosis was pyloric or gall-bladder tumor. When the abdomen was opened above the um-

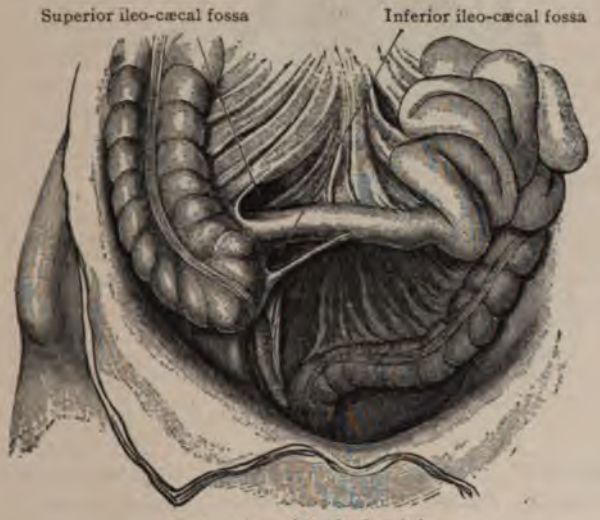


FIG. 767.—(*Zuckerkandl.*)

bilicus, the small intestines presented *in front* of the great omentum, the transverse colon, and the stomach. When the small intestine was pulled out of the belly cavity for inspection, the cæcum and vermiform appendix followed, appearing *above* the lesser curvature of the stomach. The case was one of hernia through the recessus duodenojejunalis; the gut passed up behind the stomach and then forwards through the gastro-hepatic omentum. Reduction was easy, and the duodenojejunal opening was closed by a few stitches of catgut.*

3. Pericæcal fossæ. Three fossæ exist in the neighborhood of the ileo-cæcal junction (Fig. 767): (*a*) Ileo-colic fossa, which lies above the ileum and below the ileo-colic fold containing the colic branch of the ileo-colic artery. (*b*) Ileo-cæcal fossa. The orifice of this fossa is situated below the ileum, where it joins the cæcum. The fossa may be large and extend upwards posterior to ascend-

* For extended information on this subject the reader is referred to Freeman's paper already mentioned, to Moynihan's work, "Retroperitoneal Hernia," London, 1906, to Jonnesco's "Hernies internes rétro-peritonéales," Paris, 1890. Vautrin, "Les Hernies Paraduodenales," Rev. de Chir., Jan., 1907. Desjardins "Mayo Clinics. 1917."

ing colon as far as the right kidney. (*c*) Subcæcal fossa. This fossa lies beneath the cæcum and external to the meso-appendix and meso-cæcum. Any one of the pericæcal fossæ may be the site of an internal hernia, especially if its normal relations have been altered by attacks of appendicitis. The fossæ are also of surgical importance, as they may be filled with the products of inflammation in appendicitis, and into one of them the appendix itself may be herniated.

4. The intersigmoid fossa (Fig. 768). On the lower or left surface of the meso-sigmoid a fossa may exist which is variable in size. A few cases of hernia have been described in which this fossa formed the sac.

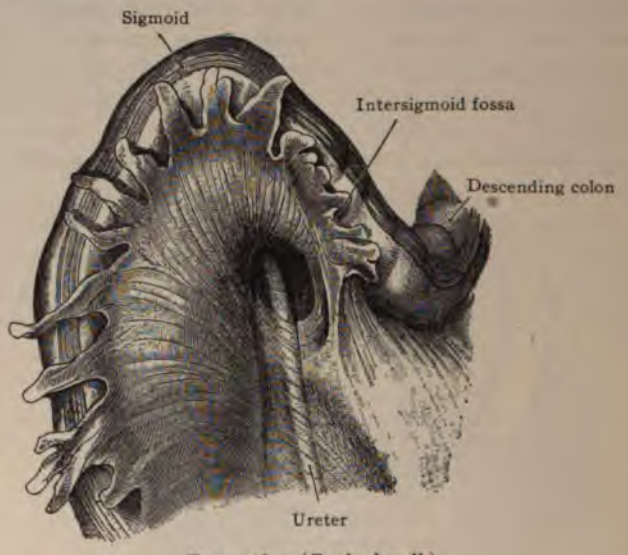


FIG. 768.—(*Zuckerkandl.*)

Many operations have been undertaken for the treatment of obscure intestinal obstruction, chronic or acute, and in many of these, symptomatic recovery has ensued, although no cause was discovered during the operation. Undoubtedly in many of these cases an internal hernia has been overlooked or has been reduced, unknown to the operator, by the manipulations necessary in exploration.

This short chapter has been written to direct the attention of the junior surgeon to the probable sites of internal herniæ. The author believes that internal herniæ are very much more common than statistics would indicate.

LARGE HERNIA

Occasionally herniæ become so large and contain so many organs that these organs may be said to have lost their right of domicile in the abdomen, and hence reduction, whether operative or non-operative, becomes impossible or unjustifiable. In other cases adhesions uniting the hernial contents to each other and to the sac constitute a condition which, either alone or in combination with a poor state of the general health, contraindicate any attempt at reduction. In such cases when strangulation or obstruction becomes evident, what means have we to overcome their disastrous results?

If the strangulation is due to constriction at the hernial orifice, common sense tells us to divide the constriction by free, open incision, and, contrary to the practice in "radical cure," to endeavor to retain the increased patency of the opening between the abdominal cavity and the hernial sac. In other words, our aim ought to be to make the abdominal cavity and hernial sac as nearly as possible one.

Usually in large herniæ nature has so dilated the abdominal orifice that strangulation at this point is rare. It is more common to find that adhesions, bands, diverticula, etc., in the hernial sac itself are the cause of strangulation. As Madelung ("Archiv f. klin. Chir.," lxxiv, 60) points out, gangrene may be far advanced in herniæ of this class, and symptoms be almost absent; thus during operation one may be compelled to excise a considerable amount of diseased gut, joining the afferent and efferent sections by anastomosis or enterorrhaphy, or may establish a fæcal fistula. Some surgeons have, on general principles, excised a mass of herniated gut, so that reduction of the remainder became possible and a radical cure could be effected.

In very large herniæ there is always some obstruction to the onward passage of fæces; this obstruction varies from time to time. Mild exacerbations are usually successfully treated by purgation, enemata, rest in bed, massage, etc., but occasionally operative interference becomes necessary. Madelung writes: "In many cases, especially the old and feeble, when coprostasis has continued for a long time, it is very proper to establish a fistula in the afferent gut. Under local anesthesia this is absolutely without danger even in the most debilitated. The fistula should be small, about the size of a medium-sized Paquelin cautery point. It should drain only part of the intestinal contents, acting as a kind of safety-valve." When the patient is strong enough to withstand a more severe operation, intra-abdominal anastomosis between the afferent and efferent loops of gut serves to segregate or exclude the affected viscera (see "Intestinal Exclusion"). It is, of course, impossible to formulate precise rules for the operative treatment of irreducible herniæ, but it is hoped the above brief remarks may aid the inexperienced practitioner in an emergency.

DIAPHRAGMATIC HERNIA

The diaphragm is the site of several actual or potential openings, the principal one being that between the costal and sternal origins of the muscle and known as the foramen of Morgagni. Hernia through Morgagni's foramen is known as parasternal hernia, and is provided with a double sac, of pleura and peritoneum. For our purpose it is useless to differentiate between the so-called true hernia and the false, where, owing to injury, there is a prolapse of abdominal organs into the thorax. Few diaphragmatic herniæ present marked symptoms prior to strangulation. Bérard and Dunet (Lyon Chirurg., XV, 509) think the only striking early symptom is painful thoracic tension with gurgling especially noted when the patient is lying down after a meal. Until the advent of the *x*-ray the diagnosis of diaphragmatic hernia was a rarity and its discovery usually dependent on operation or autopsy. The commonest cause of diaphragmatic hernia is trauma, usually from knife or bullet, and the proper

treatment is immediate operation. In Lacher's statistics of 36 traumatic cases not submitted to operation, 15 died from hernia after periods varying from a few days to a month, and 10 died in from five to twenty years from the same cause. A wound of the diaphragm when left to itself may heal, but the scar remains weak and hernia is the common result. This being true, the best treatment for traumatic diaphragmatic hernia is prophylactic. The wound of entrance is almost always in the thorax. Enlarge the wound, excise two inches or more of one or two ribs, as may be required, to give room. Note if the pleura is or is not injured. In a case operated on by the writer the pleura was uninjured, though the diaphragm was penetrated and omentum was present in the thorax. Expose and examine the diaphragm. If the diaphragm has been penetrated and omentum or hollow viscera present, examine and repair any injury thay may have sustained. Open the abdomen either by a median or lateral incision, or, as Neugebauer ("Archiv f. klin. Chir.," lxxiii, 1014) did, by a cut dividing the costal arch. It is usually easier to reduce the prolapsed organs after the abdomen has been opened, and it is necessary to explore the abdomen in search for further injuries. If no abdominal contents are prolapsed through the diaphragmatic wound, open the abdomen and search for any injuries to its contents. If the liver is injured, treat such injuries *secundum artem*. Close the wound in the diaphragm with sutures introduced by the transthoracic route. Close the wound in the abdomen and thorax with or without drainage. In 52 cases of diaphragmatic suture (where there was no *strangulated hernia*) the mortality was 9.6 per cent. when the transthoracic route was adopted; in 10 similar cases when the abdominal route was used the mortality was 50 per cent. Of the cases of strangulated diaphragmatic hernia collected by Neugebauer, all those operated on through the abdominal route died; one out of two operated on through the thorax lived. Two cases of non-strangulated diaphragmatic hernia submitted to radical cure (Llobet's and Cranwell's) lived after a transthoracic operation.

Donald Balfour (personal communication) has operated successfully by the abdominal route.

When operation is performed for obscure abdominal lesions, one ought to remember and look for diaphragmatic hernia, and if such is found, one ought *not* to waste time endeavoring to reduce it from the abdominal side, but proceed at once to open the chest. Suture of the diaphragm from below is extremely difficult and necessitates very much disturbance in a region rich in important nerves. Prolapsed masses which it is impossible to reduce from the abdomen alone are easily reduced or slip back of themselves as soon as the chest is well opened. That the dangers from pneumothorax are not so great as is usually imagined is shown by the small mortality (9.6 per cent.) after recent wounds of the thorax. Furthermore, if the hernia is reduced through the abdominal route, pneumothorax must occur immediately the hernia ceases to plug the diaphragmatic wound, while the establishment of pneumothorax prior to reduction aids marvelously in obtaining this reduction.

Cranwell ("Rev. de Chir.," Jan., 1908) recognized the presence of a diaphragmatic hernia before he operated. His patient was placed on his side in the reversed Trendelenburg posture. The lower and lateral part of the thorax

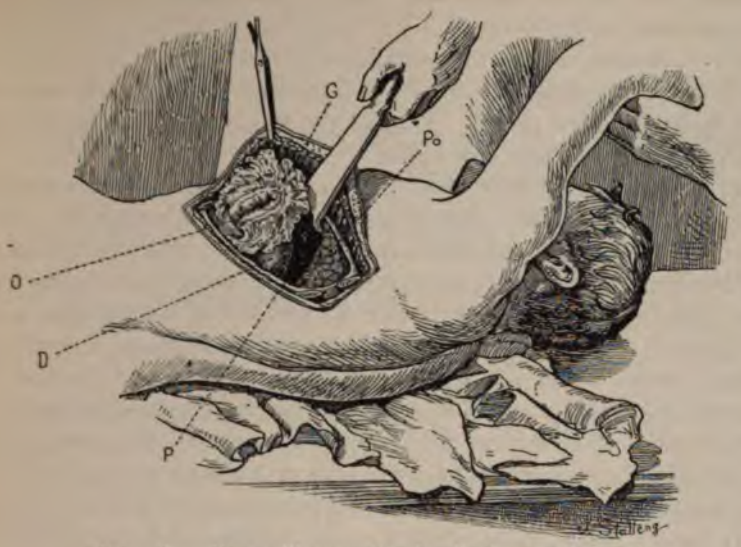


FIG. 769.—Cranwell's operation for diaphragmatic hernia.
P. Pleura. *D.* Diaphragm. *O.* Omentum. *C.* Colon.

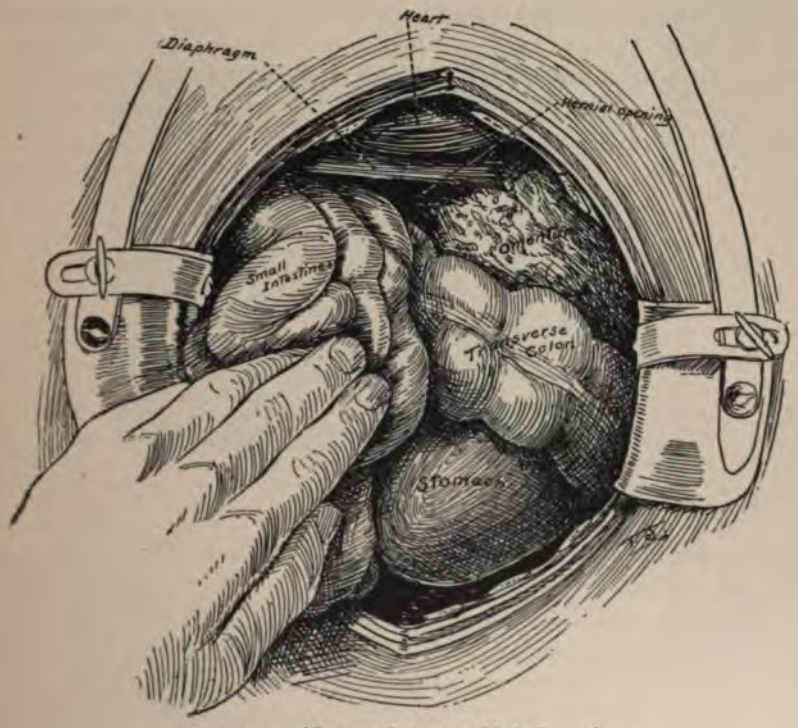


FIG. 770.—(*Carson, Interstate Med. Journ.*)

was opened by a flap having its base above, consisting of the whole thickness of the chest-wall and containing about 5 inches of the ninth and eighth ribs (Fig. 769). In spite of numerous adhesions the prolapsed omentum and colon were reduced, the openings in the diaphragm and in the pleura were sutured and the external wound closed. The patient recovered. The hernia was due to an old stab-wound which had healed.

N. B. Carson ("Interstate Med. Journ.," April, 1912) reports a successful operation for diaphragmatic hernia (supposed to be of congenital origin), in which a correct diagnosis was made prior to operation. Insufflation anesthesia was used and the intrathoracic structures were prevented from drying by being smeared with vaseline. The use of Carrel's vaselinized silk napkins to protect the lungs, etc., was found impracticable. It was necessary to resect several ribs before proper access was obtained. Fig. 770 shows the exposure of the hernia which consisted of small intestines, stomach, colon and omentum. Reduction was effected only after the abdomen was also opened. After suture of the diaphragm the wound in the chest wall was closed in layers, but before closing, the pressure was raised and the lung fully expanded.

O. J. Seibert (Surg., Gyn. Obst., Oct., 1916) diagnosed and operated upon a hernia of the stomach into the posterior mediastinum directly behind the heart. The abdominal route was chosen (it is difficult to imagine how success could have been attained in this case by the thoracic route). The hernial opening was the œsophageal diaphragmatic lacuna and the pylorus was fixed to this by dense fibrous bands which required division before reduction was possible. After reduction the opening was closed sufficiently with chromicized catgut sutures and the stomach was fixed to the anterior parietes by a couple of stitches. Recovery ensued.

PART IV.—THE GENITO-URINARY SYSTEM

CHAPTER XLVII

OPERATIONS UPON THE KIDNEY

METHODS OF EXPOSING THE KIDNEY

. Posterior or Lumbar Route.—There are two positions in which the ent may be placed:

(*a*) The classical or lateral posture. Place the patient upon this sound side ı his back near the edge of the operating table and his thighs and knees well ed. To increase the space between the thorax and ilium, place a roll- ped, firm pillow under the loin of the sound side. The surgeon stands at the ient's back.

(*b*) The prone position. This position is the best for most purposes. Lay patient prone upon the table. Place a large pillow (Edebohls' air-cushion,

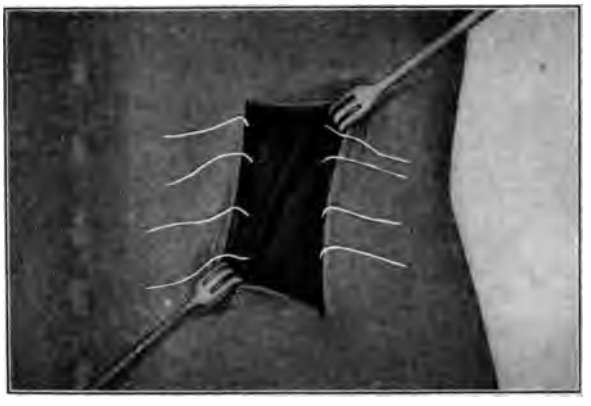


FIG. 771.—(*Edebohls, Annals of Surg.*)

nches long by 8 inches in diameter, is excellent) beneath his abdomen with its g axis at right angles to the long axis of the body. This lifts the kidneys to the field of operation and gives the widest possible costo-iliac space. The erating table referred to as suitable in operations on the bile ducts is of value re to replace sand-bags and cushions (see p. 563).

(A) *Vertical Incision* (Simon).—Recognize the last rib and the erector pinæ muscle. Make a vertical incision from the last rib downwards, parallel nd close to the outer edge of the erector spinæ muscle. This penetrates the kin and subcutaneous tissue and extends nearly to the crest of the ilium. The

latissimus dorsi is now seen. *Separate* but do not cut its muscular fibres (Figs. 771 and 772). The erector spinæ muscle presents. Retract it inward, but do not open its sheath. Expose and open the sheath of the quadratus lumborum along its outer margin for the full length of the wound. As the pleura occasionally extends below the last rib, it is wise to avoid the neighborhood of this rib while making deep dissection. By keeping one inch below the rib, all danger to the pleura is avoided and at a little later period in the operation the wound can be safely enlarged upwards under guidance of the finger. As soon as the fascia lumborum or transversalis fascia, lying in front of the quadratus lumborum, is divided, perirenal fat bulges into the wound. Remember that the last thoracic, iliohypogastric, and ilioinguinal nerves lie between the quadratus muscle and the kidney. These nerves, when met with, should be carefully pulled aside, or if it is necessary to divide one of them, the severed ends ought to be caught up in a suture, so that when the operation is completed and the wound is being closed, they may be once more united (Edebohls). Failure to attend to this point may lead to an annoying and persistent pain in the thigh after operation. When the perirenal fat is exposed, tear through it and expose the kidney.

FIG. 772.—(*Esmarch and Kowalzig.*)

1. External oblique. 2. Internal oblique. 3. Transversalis. 4. Transversalis fascia. 5, 6, 7. Lumbo-dorsal fascia. 8. Sacrospinalis. 9. Quadratus lumborum. 10. Psoas. 11. Colon. 12. Pancreas. 13. Kidney. 14. Spleen.

If the above incision does not give sufficient room, make a small transverse incision through the outer fibres of the quadratus muscle near the ilium; this simple proceeding is of great aid. To gain more room, some surgeons have recommended excision of the last rib, but this has not proved of much value. A better suggestion has been made, namely, to fracture the last rib and turn it upwards. It is easy to deliver the kidney on to the back through this incision.

(B) *Oblique Incision* (Bergmann).—From the outer edge of thee rector spinæ, at the level of the twelfth rib, make an incision downwards and outwards towards the junction of the outer and middle thirds of Poupart's ligament. The length of the incision varies with the work to be done and the size of the operator's hand. It must be large enough to give free access to the kidney. A cut four inches in length is generally sufficient for exploratory purposes and may readily be enlarged. The lower border of the latissimus dorsi presents and must be divided. Layer by layer cut through the external oblique, the internal oblique, the transversalis muscle. Under the last-named muscle lies the transversalis fascia. Make a small opening in the fascia and, guided by the finger passed through the opening, divide it for the whole length of the wound. The quadratus lumborum lies at the upper and inner part of the wound and is either retracted towards the spine or divided, as may be convenient. After division

ansversalis fascia the perirenal fat presents and is torn through until ey is reached. During the deeper dissection care must be taken not the pleura should it descend below the last rib.

Triangular incision (König).—From the outer edge of the erector spinæ, vel of the twelfth rib, cut downwards parallel and close to the erector ntil the iliac crest is reached. From the lower end of the wound make a ncision directed towards the navel and reaching to the outer margin etus abdominalis. The division of the deeper structures is carried out anner already described. Any parietal peritoneum which may be s pushed aside. Very free access to the kidney or to tumors of that attained.

Zuckerkandl's Incision.—From the ge of the erector spinæ, at the level welfth rib, cut downwards to the the iliac crest; from the latter point ards to near the anterior superior the ilium. The deep dissection is lready described.

FIG. 773.—(*Mayo.*)

Trap-door Incision (Bardenheuer).—e upper and lower extremities of the incision (A) make horizontal cuts o the lower edge of the thorax and ac crest respectively. If these cuts ards, a trap-door is formed which eflected or retracted anteriorly; if backwards (*i.e.*, towards the spine), one which can be turned back- the result. In some cases it may be desirable to form both an ante- a posterior trap-door flap.

d the peritoneum be opened during the operation, it ought to be closed y suitable sutures.

T. Parkes' Incision.—Make a curved incision from a point two inches e anterior superior spine to the tip of the last rib. Expose the fascia alis. With the finger dissect well behind the tumor of the kidney. eparated all parts, make a straight incision backwards from the first alf-way between the crest of the ilium and the last rib. An excellent is obtained of the kidney, vessels, and ureter.

Mayo's Incision.—("Annals Surg.," Jan., 1912.)

1.—From a point 2 to 2½ inches external to the dorsal spines near the rgin of the erector spinæ over the twelfth rib, or even higher, make an lownwards and forwards along the anterior margin of the quadratus n to a point about 1 inch above the crest of the ilium (Fig. 773). From point continue the incision forward parallel to the iliac crest as far as r. Divide the skin, superficial and posterior layer of the lumbo- cia which covers the erector spinæ muscle.

2.—Expose the posterior superior lumbar triangle just beneath the lb by cutting an opening through the external and internal oblique,

transversalis and latissimus dorsi muscles. Open the transversalis fascia fr and so expose the perirenal fat. Clear the twelfth rib in its posterior asp upwards and backwards nearly to its articulation. Push the pleura upwa Retract the rib upwards and the erector spinæ backwards (Fig. 774). T gives remarkably good exposure and very much simplifies all operations on kidney possible through the lumbar route. If necessary the twelfth rib may dislocated or fractured to permit even greater exposure.

FIG. 774.—(*Mayo.*)

II. Anterior or Abdominal Route.—If the kidney to be exposed is *very* larg an incision may be made over the tumor at any place which may seem suitab or advisable. Such an incision will be either vertical or oblique (running fr above downwards and inwards). Langenbuch's incision will generally be fou to be the best, as it gives free access to the renal vessels and avoids unnecessa exposure of the intestines. Küster makes it a rule to operate by the transp toneal route in cases of neoplasm when difficulties and adhesions are present the tumor is very mobile he chooses the lumbar route.

Langenbuch's Method.—From a point immediately below the ribs and ab three inches from the middle line cut downwards for a distance of four inc Find the outer edge of the rectus muscle (linea semilunaris). Cut down

the peritoneum, following the semilunar line. Open the peritoneum carefully in the same manner as a sac is opened during a herniotomy. Introduce the hand and examine the opposite kidney and ureter. This is a most important precaution, and must always be observed. The opportunity afforded to examine the opposite kidney constitute one of the advantages of the abdominal route over the lumbar. Von Eiselsberg convinced himself by touch of the hand in the abdomen that the second kidney was present, yet after nephrectomy the patient died from uremia. Autopsy showed absence of the other kidney, the surgeon having taken an induration of the pancreas to be a kidney. The opposite kidney and ureter being found healthy, the intestines are covered with a large flat gauze pad and kept out of the way. The outer surface of the mesocolon is exposed and a small hole made in its outer layer. This hole is enlarged by tearing. The vessels which pass through the mesocolon lie close to its inner layer, and thus injury to them is avoided. Through the opening in the mesocolon the kidney is easily and completely exposed.

Rutherford Morison's Incision.—Open the abdomen through the rectus muscle. Make a transverse incision from this back to the centre of the ilio-costal space. Morison writes: "This allows pus to escape behind and away from the peritoneum, perfect drainage after, and good access to vessels and ureter during operation." It also permits exploration of the opposite kidney at the beginning of the operation.

Nephropexy or Nephrorrhaphy.—*Method I.*—Expose the kidney by incision A or B. Excise most of the fatty capsule lying posterior to the kidney. An assistant with his fist pressing on the belly pushes the kidney up into the loin. Pass a curved needle, armed with a thick suture, through the muscles and fascia of the back which form the outer edge of the wound, through the remnants of the fatty capsule and into the kidney parenchyma near the outer convex border of the kidney. The needle penetrates the kidney to a depth of about one-half inch and emerges at a point about three-quarters of an inch internal to its point of entrance. After emerging from the kidney the needle passes through the remnants of the fatty capsule and the muscles and fascia of the back which form the inner edge of the wound. Three such sutures are put in place, one at the upper end of the kidney, one at the lower, and one in the middle; but none of them are tied. The deep parts of the wound in the back are now approximated by buried sutures. When this is done, the three sutures which pass through the kidney are *carefully* tied. No pulling upon these important sutures is allowable, otherwise they would cut their way out of the friable kidney. This is the reason for closing the deep parts of the lumbar wound (*i.e.*, the parts through which the kidney sutures pass) before the kidney sutures themselves are tied. The superficial wound is closed. Some surgeons, notably Newman, pass a drainage-tube through the wound to the kidney so as to produce a local irritation and thus aid in the formation of adhesions. *Suture materials:* Mildly chromicized catgut, kangaroo tendon, silk or silkworm-gut.

Method II.—Is the same as Method I, except in one particular: after the kidney is exposed a longitudinal incision is made through the fibrous capsule, which when turned outwards and inwards like the lapels of a coat, forms

an outer and an inner flap. The parenchyma of the kidney is thus left exposed for a width of about three-quarters of an inch throughout almost the whole length of the posterior surface of the organ. The sutures are introduced as before, except that when entering and leaving the kidney they pass through the folded flaps of fibrous capsule.

The advantages claimed for this method are (*a*) that better union takes place between the kidney and the muscles and fascia at the back; (*b*) that the threads passing through the folded back flaps of fibrous capsule are less liable to cut their way out. The objections urged against the method (especially by Albarran) are (*a*) that decortication is unnecessary; (*b*) that sclerotic changes are more liable to occur and injure the kidney.

Method III.—The kidney is exposed by incision B. At a point opposite the lower extremity of the kidney (when it is pushed up into its normal position) a pocket is formed by separating the transversalis fascia from the more superficial structures. Into this pocket the lower end of the kidney is snugly tucked. One or two sutures unite the kidney to the surrounding muscles and fascia and the wound is closed. Pean is a supporter of the above operation.

FIG. 775.—Israel's nephropexy.

Method IV (Israel's).—Expose kidney by incision A. Recognize the last rib. Split the fibrous capsule of the kidney so as to lay bare a narrow strip of cortex reaching nearly the whole length of the organ. Through the upper part of the posterior surface of the kidney pass a *double* suture of thick catgut (Fig. 775, A A¹, a a¹). Cut the loop of the suture so as to leave four ends of suture on which needles are to be threaded. Make a knot on the double thread of catgut where it enters and where it leaves the kidney (*z*–*z*). One of the threads emerging from the outermost part of the kidney, having been armed with a needle, is passed, first, through the fatty capsule of the kidney, and then between the periosteum and the posterior surface of the twelfth rib (Fig. 775, A A¹). The other end of thread emerging from the kidney at the same point is passed subperiosteally in front of the twelfth rib in such a manner that the two ends surround the rib under its periosteum. The two threads are knotted together. The two ends of the catgut threads which emerge from the inner part of the posterior surface of the kidney (a a¹) are separately passed through the fatty capsule, and the muscles and fascia on the inner side of the lumbar wound. These two ends of suture are now tied together, care being taken not to tie so tightly as to make the thread cut through the renal tissue. The result of the above manœuvre is to sling the kidney by a double thread the outer end of which surrounds (subperiosteally) the twelfth rib; the inner end is fastened to the muscles and fascia forming the inner wall of the lumbar wound. Two more double catgut sutures are passed through the kidney in the same manner and their loops cut so that each double suture becomes two

distinct sutures passing through the kidney together. The ends of suture emerging from the inner part of the kidney are each separately passed through the muscles and fascia on the inner side of the wound (B B^1, C C^1) and there tied together; those emerging from the outer part of the kidney are similarly passed through the muscles and fascia on the outer side of the wound (c c^1, b b^1) and there tied. The threads emerging on the inner side are tied together; *none* are tied across the wound. The lumbar wound is closed by deep and superficial sutures.

Method V (Jonnesco's Operation).—*Step* A.—Beginning at the outer edge of the erector spinæ muscles, make an incision from four to five inches along the inferior border of the twelfth rib. If the twelfth rib is short, the incision is continued along the eleventh rib. Expose the whole of the twelfth and if necessary part of the eleventh rib. Cut through the transversalis fascia and expose the kidney, which an assistant presses up into the wound. Excise most of the fatty capsule. Split the fibrous capsule of the kidney longitudinally and turn outwards and inwards an outer and an inner capsular flap (as in Method II).

FIG. 776.—Jonnesco's nephropexy.

Step B.—Pass a curved needle (Emmet's needle) through the following structures in the order named—the skin (one inch distant from the lower edge of the wound), muscles of sacro-lumbar mass, deep aponeurosis, folded inner flap of renal capsule (formed in Step A), the kidney parenchyma, the folded outer flap of renal capsule, the periosteum of the external surface of the twelfth or eleventh rib, and the muscles and skin of the superior edge of the wound (Fig. 776). Thread into the needle the end of a silver wire suture; withdraw the needle. Reintroduce the needle in the same manner at a point ½ inch distant and pull through the other end of the silver wire suture. The result is that a U suture is in place. Two such suffice. Through the loop of each U is placed a small rod or pad of gauze to prevent the skin being cut. The other ends of each U suture are twisted together over a pad of gauze. No tension is put on the sutures lest they cut the kidney tissue; their function is to suspend the kidney.

Step C.—Close the wound with catgut or silkworm-gut sutures.

The dressings are left untouched for ten days, after which time all the non-absorbable sutures are removed.

Method VI (Edebohls' Operation).—*Step* 1.—Expose the kidney by Method A, patient being in prone position

Step 2.—Deliver the kidney through the wound and excise the fatty capsule.

Step 3.—Decapsulate the kidney and introduce suspension sutures of forty-day chromic gut, as shown in Fig. 777.

Step 4.—Reduce the kidney and pass the sutures from within outwards through the whole thickness of the parietes except the skin and tie them as in Fig. 778.

Step 5.—Close the lumbar wound.

In performing this operation do not endeavor to anchor the kidney at high a level as its normal site, and be careful not to cause any kinking of t

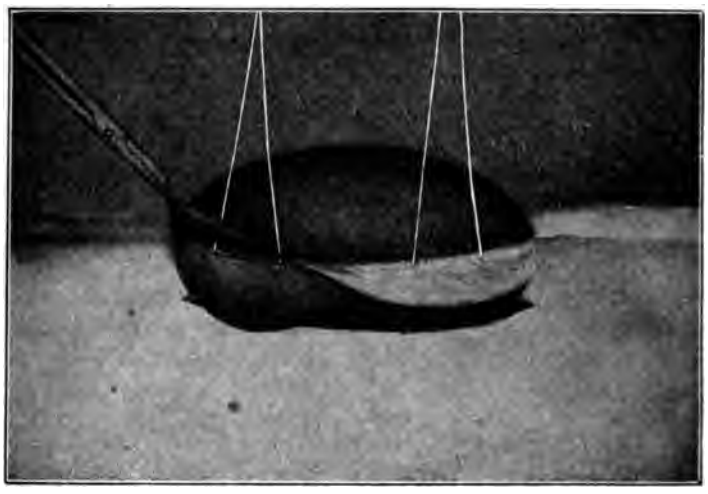


FIG. 777.—Edebohls' nephropexy. (*Edebohls, Annals of Surg.*)

ureter. The main principle of the operation is to bring a large area of deco cated kidney into contact with a corresponding area of the quadratus mu= denuded of its fascial coverings.

FIG. 778.—Edebohls' nephropexy. (*Edebohls, Annals of Surg.*)

Method VII.—Albarran ("La Presse Medicale," 21, Aug., 1906) that a good operation must fulfill the following conditions: (1) Perm tion of the kidney and ureter. (2) Place the kidney in good position the kidney thoroughly. (4) Injure the parenchyma as little as possi

The Operation.—Step 1.—Expose the kidney by Method B. through the perirenal fat it is not necessary to remove any of it.

ng the fat from the lower pole of the kidney an incision through it at gles to the original wound is of great service.

2.—Deliver the kidney on to the back. Explore it by sight and palpa- Gross changes are easily made out. When there is slight hydronephro-

FIG. 779.—Albarran's nephropexy. (*La Pr. Med.*)

FIG. 780.—Albarran's nephropexy. (*La Pr. Med.*)

kidney is not so firm as usual, and it is easy to bend it a little on itself, s impossible in the normal organ. Examine the upper end of the ureter ks or bends are present or lest fibrous bands cause obstruction. Correct alities.

Step 3.—Decorticate the kidney completely, making the reflected true capsule form two flaps (anterior and posterior).

Step 4.—Divide the anterior flap into two parts (upper and lower) (Fig. 779). Ligate each of these parts with strong chromicized catgut (Fig. 780), leaving both ends of the catgut long. Treat the posterior capsular flap in the same manner.

Step 5.—Retract the lumbar muscles inwards and expose the twelfth rib. With a needle draw one end of each of the ligatures attached to the upper portions of the capsule round the rib and tie it to the same end of the other ligature (Fig. 780). This suspends the upper pole of the kidney to the rib. One-third of the long diameter of the kidney ought to be now hidden by the ribs. If it is impossible to pass the sutures round the twelfth rib, fix them to the *external* periosteum of the eleventh rib and to the costo-vertebral ligament. Before tying the sutures see that the kidney is so placed that the ureter is free from kinks and will drain the lowest point of the pelvis.

FIG. 781.—Albarran's nephropexy. (*La Pr. Med.*)

Step 6.—Fix the ligatures attached to the lower portions of the capsule to the muscles on each side of the wound. Fig. 781 explains this step.

Step 7.—Provide for drainage—close the wound with sutures.

In all the preceding methods of nephropexy the aim of the surgeon has been to suture or sling the kidney to the posterior parietes. Harris has shown that in cases of mobile kidney there is a separation of the posterior peritonum from the parietes, and that the attachments of the ascending mesocolon are loosened. The result is an absence of normal support to the kidney and the presence of ptosis of the ascending colon.

Harris' Operation.—Place the patient in the prone position; expose the kidney and bring it out through the wound. Retract the edges of the wound and observe the post-peritoneal cavity into which the kidney has been in

the habit of gliding and note the position of the ascending colon. By a few carefully placed catgut sutures obliterate the above-named space, and the essential element of the Harris operation is completed. Prepare the kidney for suture, reduce it, and fix it to the parietes by one of the methods already described.

The Harris operation was the first in which any attention is paid to the fact that nephroptosis is often merely one part of a condition of general visceral ptosis, and in which an endeavor is made to correct part of the visceral ptosis by fixation of the colon (colopexy) while the post-peritoneal space is being obliterated. Willard Bartlett obtains the objects of nephropexy in an indirect manner. His argument is that if one can fill up the hole into which the mobile kidney slides ptosis becomes impossible.

Step 1.—Expose the perirenal fat through any appropriate posterior incision.

Step 2.—Without at this time exposing the kidney, separate the perirenal fat from the anterior surface of the muscles of the back. Continue this separation forwards until the peritoneum is reached. Separate the fat from the peritoneum up to the pelvis of the kidney.

Step 3.—Carefully penetrate the perirenal fat near the convex edge of the kidney. Insert a catgut suture, as a purse-string, into the perirenal fat around this hole which has been made in it.

Step 4.—Deliver the kidney on to the back through the tear in the perirenal fat. Push the capsule of perirenal fat towards the pelvis of the kidney until it lies like a ruff around the renal pedicle. Tighten and tie the purse-string suture taking great care not to compress the renal pedicle. Leave the end of the suture long.

Step 5.—Push the mass of fat into the depth of the wound and reduce the kidney. Fix the end of the purse-string suture to the anterior-inferior end of the wound in the parietes. Close the wound. The mass of fat compels the kidney to retain its normal position and is much aided in this by the adhesions which form between the kidney and the muscles of the back.

Mobile kidney is exceedingly common, and in the majority of cases presents no symptoms. When symptoms are present, they may be really those of neurasthenia, in which case fixation of the kidney can scarcely be expected to do more than give mental relief. Of course, cases do occur in which the mobility of the kidney is the causative factor, where tension exerted on the structures at the hilus gives rise to trouble and where kinking or displacements of the ureter occasion distressing symptoms and conditions. It is in this comparatively small class of cases that nephrorrhaphy gives gratifying results.

G. Percival Mills (Proc. Royal Soc. of Med., Feb., 1914, Surg. Sect.) reviewed all the cases of nephropexy performed in the General Hospital, Birmingham, during 1909–1912, and came to the following conclusions which support the opinions expressed by the author in the preceding paragraph;

1. "The general results of the operation of nephropexy are bad.

2. Nephropexy has very frequently been performed to relieve symptoms that are not due to the movable kidney; this is proved by the persistence of the symptoms after a successful operation.

3. The symptoms due to a movable kidney are chronic lumbar pain of the renal type described, which is absolutely relieved only by horizontal rest. These symptoms, if present alone, are nearly always cured by nephropexy.

4. When lumbar pain is associated with neurotic symptoms, nephropexy rarely gives relief.

5. Nephropexy fails to cure cases of dyspepsia which are supposed to be due to the obstruction of the duodenum by a movable kidney.

6. The indications for nephropexy in a case of movable kidney are as follows:

a. Intermittent hydronephrosis; (*b*) pain of the character described above; (*c*) possibly in a few cases of Glenard's disease."

Alglave ("Rev. de Chir.," Dec., 1904) describes a number of cases in which ptosis of the kidney led to a descent of the upper part of the ascending colon, the cæcum remaining fixed. The result of this is an abnormal flexing of the gut, with dilatation and most obstinate constipation. Colitis and pericolitis are commonly present, with many adhesions. According to Alglave, these accidents are secondary to the nephroptosis, but are often so thoroughly established that nephropexy is insufficient to correct them. The author has met this condition in a number of cases and has seen fair results follow liberation of the gut from its adhesions. In bad cases exclusion of the ascending colon by uniting the ileum to the descending colon (see "Intestinal Exclusion") will be found serviceable.

Many surgeons, when operating on the right side, before proceeding to treat the kidney itself in the operation of nephrorrhaphy, open the peritoneum freely, find the ascending colon, draw it out of the wound, and follow one of its longitudinal bands to the appendix. Excise the appendix whether diseased or not. In the hands of an expert this additional step consumes only a very few minutes, and as one eminent surgeon remarked to the writer, "If any operator ever gets close to my appendix, I would never forgive him should he not remove it." The same surgeons who advocate appendicectomy as a step in the operation also advocate exploration of the biliary passages as a routine measure. The inexperienced operator is advised not to add the above-mentioned steps to the operation of nephropexy, as in his hands the extra risk incurred will probably more than balance the benefits which may accrue.

To understand the advantages and disadvantages of the various methods of exploring the kidney and of removing calculi from it, a thorough knowledge of its surgical anatomy is essential. The descriptions given in many of the textbooks of anatomy are entirely insufficient for practical use at the operating table. Of course when a kidney is the site of a large collection of fluid, whether purulent or not, it can be incised and drained or excised without necessitating any exact anatomical knowledge on the part of the surgeon. The same is true when very large calculi are present. In such cases after exposure of the kidney no real exploration is required; the indications for treatment are fairly evident. When it is necessary really to explore the kidney and its pelvis, precise anatomical knowledge is essential.

The kidney may be taken to be composed of a number of conical masses of parenchyma, the secreting tubules of which open on the nipple-like apices of the

cones. These cones of parenchyma are fused together into one mass in such fashion that the apices of the cones present into a cavity (sinus of the kidney)

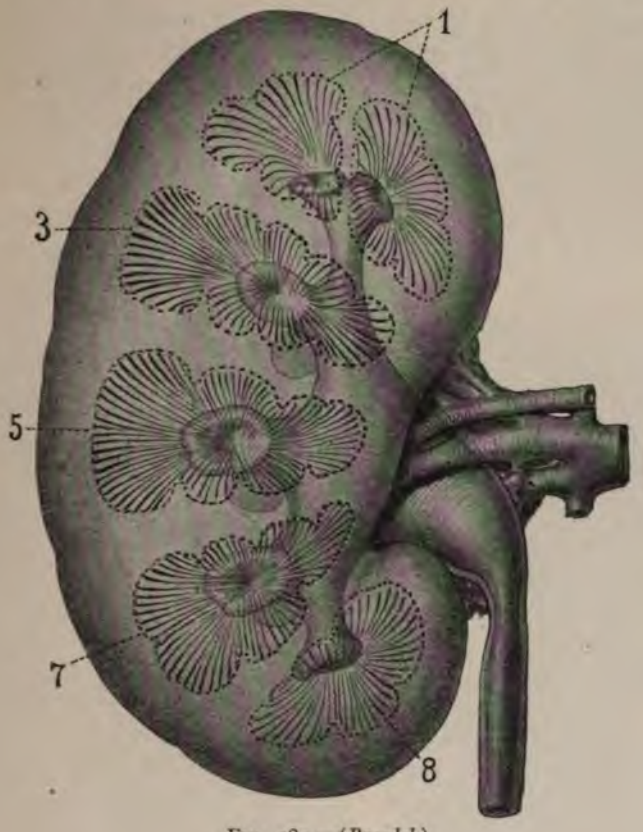


FIG. 782.—(*Broedel.*)

FIG. 783.—(*Broedel.*)

completely surrounded by parenchyma except at the inner or concave border of the organ where the sinus or cavity is open (hilum). (Figs. 782 and 783.) The ureter is a tube which runs from the bladder up to the kidney. When the

ureter comes near the hilum of the kidney it expands to form a cavity of varying size, the pelvis of the kidney. The pelvis of the kidney extends into the sinus of the kidney may be of several types.

(**A**) A number of short tubes may be given off from the pelvis, and into the open expanded end of each of these tubes (calyx) the apex of a renal cone is inserted like an acorn in its cup, so that the urine escaping from the renal tubules flows into the pelvis and so into the ureter. This is the so-called classical or *ampullary type* (Fig. 784) and occurs in about 30 per cent. of cases observed by Delbet and Mocquot. ("Rev. de Gyn. et de Chir. Abdominale," xi, No. 4, 1907.) The tubes leading from the calices to the pelvis are very short, sometimes so short that the apex of the cone may protrude into the pelvis itself.

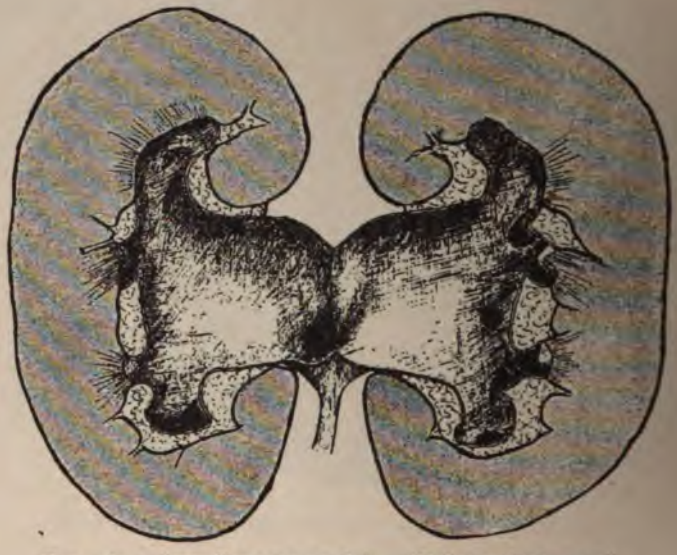


FIG. 784.—Ampullary type pelvis. (*Delbet and Mocquot.*)

(**B**) *Ramifying Type of Pelvis.*—Just inside the opening of the sinus of the kidney the pelvis may divide into tubes (primary tubes); these in turn may give off secondary tubes the open ends of which form the calices. The division of the pelvis may be (*a*) Bifid—one primary tube going to the upper pole of the kidney, the other to the lower pole. (*b*) Trifid—where the third tube goes horizontally to collect urine from the middle portion of the kidney.

A glance at Figs. 784, 785, 788 will explain the foregoing remarks. The pelvis of the kidney and its tributary tubes are attached to the inside of the sinus of the kidney merely by loose connective tissue and fat. There are no openings in the pelvis or its tributaries except the calices and these are plugged by the nipple-like apices of the renal cones. Thus the collecting apparatus (pelvis, tubes, calices) is entirely distinct from the secreting apparatus (the kidney) although it is usually almost entirely hidden within the kidney sinus. The notion is important as it shows that no exploration of the pelvis is possible by

by nephrotomy without incision of the pelvis, *i.e.*, without pyelotomy. The renal artery reaches the hilum of the kidney at a higher level than the pelvis and here divides into three or four branches (Fig. 787), one of which passes over the upper border of the pelvis and passes downwards on the posterior surface of the origin of the primary tubes (Fig. 788). This branch usually lies well inside the sinus, but it may be situated along the opening of the sinus (the hilum).

The renal artery or its branches as soon as they enter the hilum lie in contact with the kidney parenchyma to which they give off branches. They are sepa-

FIG. 785.—Trifid pelvis. (*Delbet and Mocquot.*)

FIG. 786.—Bifid pelvis. (*Delbet and Mocquot.*)

rated from the pelvis and its collecting tubes by loose fatty connective tissue and in the living body, where the tissues are much more supple than in the cadaver, they, *plus* the renal cortex bordering the sinus, can be readily retracted from the pelvis and from part of the tubes (Delbet and Mocquot).

The arteries in their distribution do *not* loop themselves round the calices. One must remember that one or more branches of the renal artery may enter the kidney through its cortical substance, away from the hilum and require separate attention during nephrectomy.

The renal vein and its branches lie between the artery and the collecting apparatus (pelvis, tubes, calices). They are as loosely connected with the latter structures as are the arteries, except that venous anastomoses occur

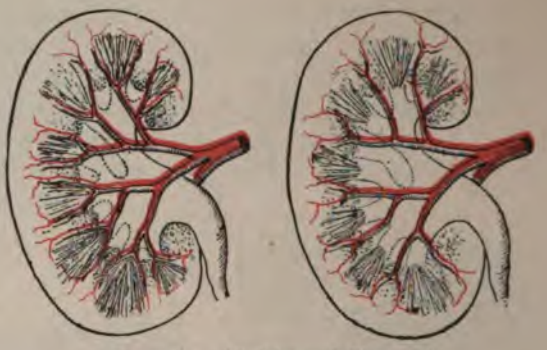


FIG. 787.—(*Poirier and Charpey.*)

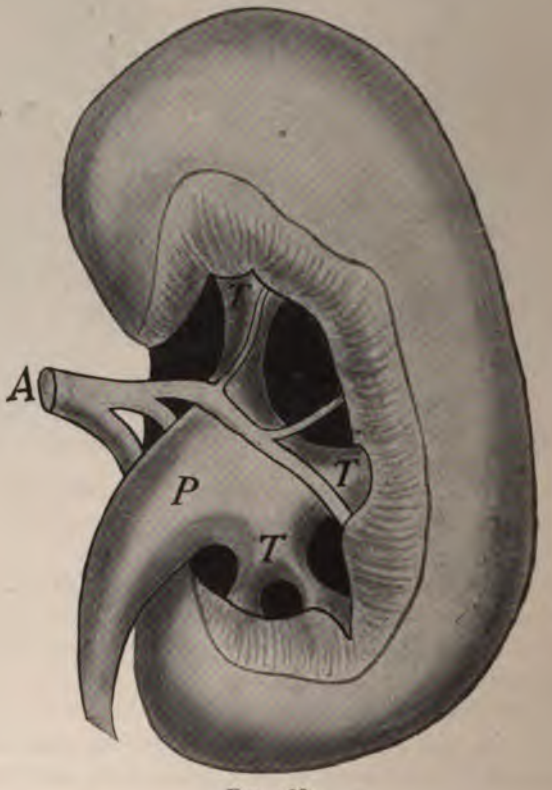


FIG. 788.

around the calices (Figs. 789 and 790). In the fatty tissue of the renal sinus lie the lymphatics and nerves of the kidney.

From the preceding paragraphs it might seem that the sinus of the kidney was always the same shape and bore the same relationship to the pelvis. This would be far from the truth.

Fig. 791 shows a kidney in which there is little notching of the inner border of the kidney and in which most of the renal pelvis lies in an accessible position,

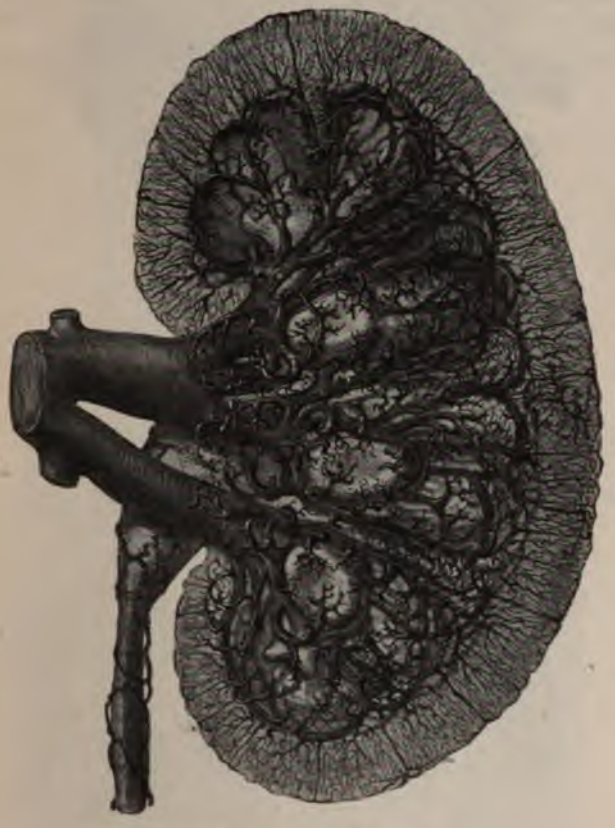


FIG. 789.—(*Broedel.*)

i.e., not inside the sinus. Fig. 792 shows a very different arrangement in which the sinus opens at the bottom of a deep, acute-angled notch. The pelvis is small and is almost completely contained within the notch and the sinus. Between these two varieties there are all sorts of gradations.

Exploration of the Kidney.—Expose the kidney, preferably by Methods A or G, with the patient in the prone position. By pulling upon the fatty capsule and by pressing on the abdomen with the hand, bring the kidney into the wound and deliver it on to the back, where it may be palpated and inspected thoroughly. Should it be impossible to safely deliver the organ (because of adhesions, etc.) separate it by blunt dissection from its surroundings, except,

of course, at the hilus, when its whole surface and pelvis may be palpated. Should the presence of calculi be suspected, but not be determined by palpation, it is often advised to perforate the organ in all directions with a fine round needle

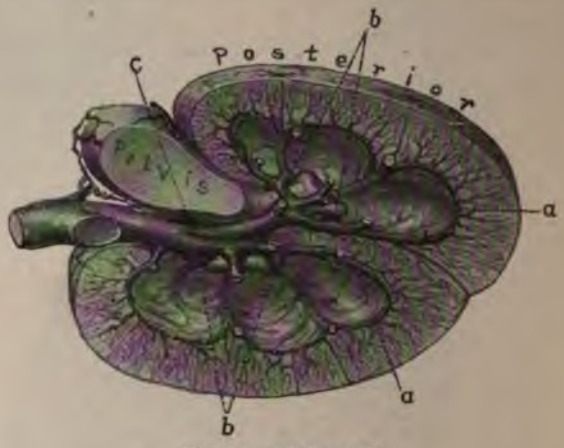


FIG. 790.—(*Broedel.*)

FIG. 791.—(*Delbet and Mocquot.*)

(lady's hat-pin). Whenever the needle touches a calculus, a sensation of grating is communicated to the hand. Should a cyst of the kidney be discovered, its contents may be obtained for examination by means of the exploring needle and syringe.

The above exploration of the kidney often fails to give the information desired, and further investigation is necessary.

Exploration of the Renal Pelvis without Pyelotomy. Delbet's Method.—Expose the kidney through the lumbar route, deliver it on to the back and place it so that its posterior surface is exposed to view and touch. Beginning at its ureteral end, free the posterior surface of the renal pelvis from its covering of loose fatty areolar tissue by blunt dissection. Push aside the areolar tissue and retract it, very gently, along with the blood-vessels and the parenchyma forming the wall of the sinus. The same dissection may be made, if necessary, on the anterior surface of the pelvis. By this means most of the pelvis, often all of it,

FIG. 792.—(*Delbet and Mocquot.*)

and sometimes the beginning of the primary tubes may be exposed to view. It is now possible to pass the finger into the sinus behind the pelvis without tearing anything and thus directly palpate the pelvis. The finger can be introduced in the middle transverse diameter of the kidney to the bottom of the sinus and can palpate the middle calices; towards the upper and lower poles it cannot be introduced so far, but it can always explore a considerable portion of the upper and lower primary tubes.

Delbet's method permits useful accurate palpation without danger; the ordinary methods of palpation unaccompanied by the dissection described are clumsy and only calculated to reveal gross lesions.

Nephrotomy.—*Step* 1.—Expose and isolate the kidney as in the operation of exploration.

Step 2.—Deliver the kidney on to the patient's back. Surround the hilus or pedicle with a rather fine rubber band or tube not too tightly applied, and fastened by tape and forceps, as shown in Fig. 793. This renders the next step practically bloodless, but entirely prevents exploration of the ureters. An intestinal clamp with rubber covered blades serves the same purpose. Instead of using the rubber constrictor, an assistant may control the circulation with finger pressure applied to the hilus, or no control of the circulation may be attempted. In some cases it is impossible to deliver the kidney safely. Under these circumstances hook the finger in front of the organ and bring its convex margin as well as possible into the wound.

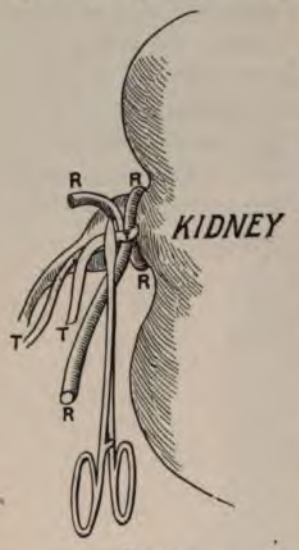


FIG. 793.

R. Rubber tube or band. T. Tape placed over the crossing-point of rubber tube, and held by forceps. It is just as good to fix the rubber by the forceps without the use of the tape.

Step 3.—Grasp the kidney between the fingers and thumb of the left hand and make a longitudinal cut along its convex border of such size and depth that the finger may be passed into the renal pelvis. If necessary, the kidney may be split open throughout its whole length, as is done at the postmortem table (Fig. 794). Introduce the finger through the wound and palpate the interior of the kidney and its pelvis; the fingers of the other hand applied to the surface of the organ aid this exploration. If the elastic constrictor has not been employed or after its removal, the ureters may be examined by ureteral catheters or bougies passed through the wound. To obviate this trouble it is proper to apply the constrictor to the vessels alone. When the active examination or operation is

FIG. 794.—(*Monod and Vanverts.*)

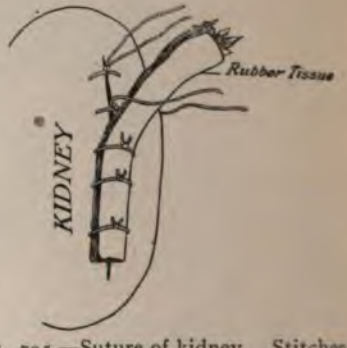


FIG. 795.—Suture of kidney. Stitches tied over rubber tissue drain.

completed, close the renal wound with a few catgut sutures introduced by a round needle, *i.e.*, one without cutting edges. The sutures stop all hemorrhage. Close the lumbar wound, in layers, with buried sutures or with through-and-through sutures of silkworm-gut. Provide for drainage if necessary. This

may be accomplished by placing a few layers of folded rubber tissue over the line of suture, and tying the ends of the catgut sutures, left long for this purpose, over the tissue (Fig. 795).

The above is the classical method of performing nephrotomy, but it takes no cognizance of the arrangements of vessels inside the kidney and hence may destroy an unnecessary number of important vessels, thus cutting off nutriment from and causing necrosis of an unnecessary amount of cortex.

The arteries are distributed to the cortex in two groups—an anterior and a posterior group. The anterior vascular region is wider than the posterior. According to Broedel, the line bb¹ (Figs. 796 and 797) overlies the principal vessels of the kidney parenchyma and in lobulated kidneys is marked by a distinct depression of the surface, over which the capsule seems thickened, forming a whitish band to which the perirenal fat may be more adherent than elsewhere. An incision (cc¹), just posterior to the lateral convex border of the kidney (aa¹) gives good access to the posterior group of calices and injures the fewest possible vessels

FIG. 796.—Broedel's line for incising kidney. (*Broedel.*)

Cullen and Derge split the kidney by passing a long, blunt, flat needle through it from pole to pole and by means of this needle introduce a fine silver wire of low tensile strength. A see-saw motion given to the wire permits it to cut its way out of the kidney without causing bleeding. The method is identical with that used by potters to cut clay. In kidneys where disease has caused the formation of areas of fibrous tissue so much pressure must be put on the wire that the resulting trauma occasions more bleeding than would be caused by the use of the knife (E. H. Richardson).

Marwedel's Nephrotomy.—Expose the kidney by the lumbar route. Deliver it on to the back. At the middle of the convex border of the kidney make a *transverse* incision through the parenchyma into the pelvis. Introduce the finger to explore. If more room is required enlarge the incision both anteriorly and posteriorly until the kidney is divided into an upper and lower half. It is now easy to so open the wound that the pelvis becomes very accessible. Marwedel claims his operation (*a*) unusually free access to the renal pelvis; (*b*) less destruction of parenchyma; (*c*) less injury to important blood-vessels and consequently less necrosis of parenchyma. Zondek shows that injury to blood-

vessels is quite as great as in the longitudinal incision. When the renal pelvis is of the ampullary type (30 per cent.) undoubtedly Marwedel's method will give perfect access to it, but when the pelvis is of the ramifying variety the state of affairs is very different and the exposure may be practically *nil*.

When nephrotomy is performed as a therapeutic measure, complete closure of the renal and lumbar wounds is almost always improper. Drainage must be provided. Drainage may be accomplished as follows:

(*a*) Introduce a wick of mildly iodoformized gauze, surrounded by rubber tissue (cigarette drain), into the portion of kidney to be drained and fix it there

FIG. 797.—Broedel's incision of kidney. (*Broedel.*)

by a stitch of plain catgut or tie the ends of one of the renal sutures around the drain (Fig. 798). This simple precaution is perfectly harmless and prevents displacement of the drain. A drain of folded rubber tissue or oil-silk without any gauze is probably better than the cigarette as gauze adheres to the tissues and may favor the formation of fistula. It is wise to leave the drain *in situ* for a week or longer.

(*b*) Use in the same manner a rubber tube split longitudinally and containing a wick of gauze. The split runs the whole length of the tube, diminishing its rigidity and thus avoiding some possibilities of injury to tissues from pressure. Do not insert the tube too deeply, as it may then cause much pain, and even reflex anuria.

(*c*) In the same manner use and fix in place a dressed rubber tube (Fig. 799).

F. Voelcker (Zent. f. Chir., 13, June, 1914) in a case of secondary hemorrhage a few days after nephrotomy, delivered the kidney on to the back, applied compressive dressings and in four days later returned the kidney to its bed. This procedure was successful and ought to take the place of nephrectomy under similar circumstances.

If the kidney is the seat of multiple abscess and nephrectomy is not indicated, open all the abscesses freely, either through the original renal incision or through individual incisions, as may be convenient. If it is believed that relief of tension may be of value in a case where nephrotomy has revealed no pathological condi-

tion sufficient to account for the symptoms, then it is wise to leave the renal wound at least partly open. A. H. Ferguson, Edebohls, and others practise decortication of the kidney when they desire to relieve tension in cases of nephritis. Their operation for nephritis consists in exposure, delivery, and decortication of the kidney. Excellent reports have been published as to the success of decortication in nephritis, but the whole question is still *sub judice*. Wounds of the kidney heal rapidly when sutured.

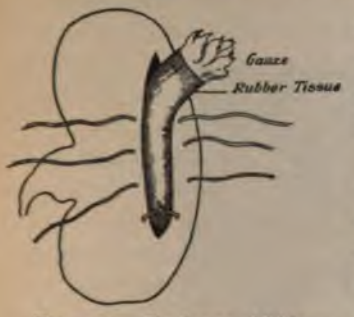


FIG. 798.—Drainage of kidney.

F. S. Watson ("Annals of Surg.," Dec., 1905; March, 1906; Sept., 1907) recommends double nephrostomy to take the place of ureteral implantations: (1) as a palliative measure in cases of inoperable vesical tumor or of vesical tuberculosis causing suffering where the infection is descending and both kidneys are involved; (2) as a preliminary to total extirpation of the bladder. After the kidney is exposed and incised, the ureter is ligated as near the renal pelvis as possible. When the urinary fistula is established, place *over* (not into) it a cup-shaped shield or funnel connected with a metallic receptacle. The receptacle can be conveniently emptied even in a public urinal by means of a rubber tube (Fig. 800).

Rovsing instead of nephrotomy practises lumbar ureterostomy as a part of complete cystectomy (see cystectomy). Wilms (of Basel) exposes the ureter at the brim of the pelvis, preferably extraperitoneally,* and brings it out of the wound about 2 inches above the anterior superior spine of the ilium. If the ureteral stump is long enough it is well to pass it through a subcutaneous tunnel for a distance of 1½ to 2 inches. After the wound has healed it is easy to cut the skin, under which the ureter runs, in the form of a flap and so to envelop the ureter in the flap of skin as to form a convenient spout (Fig. 801).

FIG. 799.—Drainage of kidney.

Nephrolithotomy.—Expose and if possible deliver the kidney as in nephrotomy. Control the renal circulation by finger pressure at the hilus or by the elastic constrictor, if this is feasible. Incise the kidney as in nephrotomy. If the stone is small and lies free in the pelvis, pass a forceps through the renal wound and extract it. When the stone is large and fills the renal calices, its extraction becomes a matter of great difficulty. Under such circumstances enlarge the incision through the kidney to the necessary extent. With the finger, peel the stone out of the calices and remove it unbroken. If its removal entire is impossible fracture it

* For exposure of ureter see Ureterotomy.

with forceps, but let the fragments be as few in number as possible. If there are many and small fragments, some of them are liable to escape extraction and cause trouble in the future. Remove all débris, with finger, spoon, forceps, gauze strips, or douche. When several calculi are present, they may often be extracted through the same renal wound, but if more convenient, they may

FIG. 800.—Watson's nephrostomy. (*Watson, Annals Surg.*)

be removed through separate incisions. It is far less damaging to the kidney to make several clean incisions through its parenchyma and thus extract the calculi with the minimum of laceration and contusion than to endeavor to take them all out through one cut. The latter plan too often results in the kidney's being converted into ragged mass lying inside a nearly perfect capsule.

The calculi having been removed, introduce and fix drains in the renal wounds, as has been described under the heading Nephrotomy. Close the nephrotomy wounds as far as necessary with catgut. Close the lumbar wound except where the drains emerge. A stone weighing four and one-half ounces has been removed in the above manner.

Pyelotomy and Pyelolithotomy.—The kidney is exposed and if possible delivered after the methods already described. The pelvis of the kidney is incised. The incision should not be located too near the renal parenchyma, for the following reasons (Israel): (1) In this location sutures are inserted with difficulty and are liable not to hold. (2) When a stone is being extracted through such a cut, the renal parenchyma may be injured, resulting in hemorrhage and subsequently renal colic from the blood-clots formed in the pelvis and ureter. After the stone is extracted, the pelvic wound is to be closed by a few catgut sutures unless drainage of the pelvis is demanded. Wounds of the pelvis of the kidney heal readily when infection is absent. The Mayos find that closure without leakage may be secured even if the suture of the pelvis is very imperfect provided the pelvic wound is covered by a flap of fatty fascia. In nephrolithiasis there is often a distinct increase in the amount of fatty tissue attached to the pelvis. If it is possible to make the pelvic incision through this fat do so, and after suturing the pelvic wound, close the fatty wound separately with fine catgut. If the pelvic wound is too large or irregular, or if the fat does not naturally cover it, it is easy to make a flap of fatty tissue from the neighborhood, lay this flap over the wound and keep it in position by a few fine catgut stitches. The lumbar wound should be drained by means of folded rubber tissue or oil-silk.

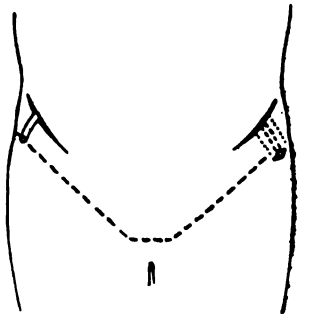


FIG. 801.—Wilm's ureterostomy.

Delbet's Pyelotomy.—"This may be necessary to permit complete exploration of the superior and inferior calices, to extract a calculus or to remove false membranes which are sometimes present in cases of pseudo-membranous pyelitis." Make an incision through the middle of the posterior surface of the pelvis in the long axis of the pelvic funnel. Do not let the incision involve the ureter, as this might cause stricture. In almost every case it is possible to make a cut large enough to admit the little finger and with it to explore all the tubes and calices. A fine scoop may be used to reach parts inaccessible to the finger. If a pelvis is too small to permit of this incision and exploration, it is fairly safe to assume that it is healthy and contains no foreign body. After completing the exploration, close the wound with fine catgut sutures; if silk is used the suturing must be of the Lembert type. Delbet uses two layers of suture; the first, of fine catgut, penetrates the whole thickness of the pelvic wall, the second, of silk, is introduced in the Lembert fashion and does not penetrate into the pelvic cavity. Simple suture with catgut is all that is really necessary, the supplemented sutures of silk do more harm than good. Payr after suturing the pelvis reflects a flap of the fibrous capsule of the kidney having its pedicle near the hilus, and sutures this flap over the pelvic wound.

Comparative Advantages or Disadvantages of Pyelolithotomy and Nephrolithotomy (Rovsing).—*Pyelolithotomy.—Advantages:* Little hemorrhage and no injury to renal parenchyma. *Disadvantages:* Stones in the calices cannot be removed. Fistulæ are liable to result and persist.

Nephrolithotomy: By means of this procedure all stones can be remov

When no suppuration exists the renal wound may be closed and heal *per primam.* If pus is present, the wound may be partially closed and drainage provided. Fistulæ when they occur are more readily closed than after pyelotomy. In many cases the hemorrhage which may occur is not of importance. Hemorrhage would be dangerous in patients weakened by prolonged disease or in cases where it is necessary to split the kidney throughout its whole length in order to remove a very large stone, were it not that the renal vessels may be readily controlled by the finger pressure or the elastic constrictor. The injury to the parenchyma inevitably incurred is of comparatively little importance.

The above are Rovsing's views, and his opinions always command respect. The experiments of Delbet and Mocquot show that it is much easier to reach every calyx in the search after small calculi by means of pyelotomy than by nephrotomy.

John Clay ("Brit. Med. Journ., May 1, 1909) recommends the following procedure in cases of double nephro-lithiasis where there is much destruction of renal tissue.

Operation.—Expose the kidney through the loin. Open the peritoneum and palpate the opposite kidney to make sure of its condition. Close the peritoneal wound. Deliver the kidney on to the back. Loosely pack with gauze the cavity from which it was removed. Extract the stones from the pelvis and calices. Attend to hemostasis. Wrap the kidney in gauze and let it lie on the patient's back draining into the dressings instead of into the loose retro-peritoneal tissues.

Operation 2.—As soon as the kidney is covered with healthy granulation tissue, replace it in its normal bed and close the wound after providing for drainage.

After a proper lapse of time the second kidney may be treated in a similar manner.

Partial Nephrectomy.—Experiment and experience show that wounds of the kidney heal readily, and that large parts of the normal kidney may be removed without noticeable ill effect. Tuffier's experiments seem to show that one-third or one-fourth of the kidney is sufficient for the performance of function.

The kidney is exposed and delivered through any of the incisions already described. The diseased portion of the organ is removed, if possible, by a V-shaped incision, so that the resulting wound may be easily closed by catgut sutures. This typical removal is often improper, as by it too much healthy parenchyma might have to be sacrificed. For disease involving the upper or lower ends of the kidney a transverse incision may suffice and sacrifice the least possible amount of healthy parenchyma. In the case of irregular multiple, but localized abscesses, where neither the V nor the transverse incision may be applicable, the surgeon contents himself with scraping and cutting away all the diseased tissue. Hemorrhage is prevented after the last two operations partly by judiciously applied sutures and partly by gauze packing. For the packing to be effectual it may be necessary to stitch the kidney to the lumbar wound. The lumbar wound is closed completely or in part, as already described.

Cases Suitable for Partial Nephrectomy.—Benign neoplasms, *e.g.*, echinococcic cysts, pyonephritic disease, etc. Note, however, that hypernephromata often

appear distinctly encapsulated and easily removed by partial nephrectomy, and yet they are very malignant in character.

Nephrectomy.—(A) *Lumbar Route.*—The kidney is exposed by one of the incisions described.

1. *Nephrectomy for malignant disease:* A good rule to adopt when operating for malignant disease is to remove too much rather than too little. The same principles which obtain in excision of the breast obtain in nephrectomy for malignant disease.

Step 1.—Expose kidney *freely.*

Step 2.—With finger dissection separate the kidney from its surroundings until it is left attached by its pedicle alone. If the organ has become firmly adherent to its surroundings, it may be easier to separate the kidney from its fibrous capsule (capsula propria) than from the fatty capsule. In such a case the fibrous capsule may be left to be treated at a later stage of the operation.

Step 3.—The pedicle is examined. The vessels and the ureter are recognized. A ligature carrier is passed between the ureter and the vessels and a double ligature of silk or reliable catgut pulled through. One of the ligatures is placed around the vessels and tied tightly at as great a distance from the kidney as possible. This is to permit division of the pedicle far enough away from the ligature to leave a stump of length sufficient to prevent all danger of the ligature slipping. The other ligature is tied around the ureter. A hemostatic forceps is applied to the pedicle between the ligatures and the kidney. The pedicle is divided close to the kidney, leaving the hemostat attached to the stump. The hemostat gives one control of the stump and is left in position until the condition of the stump has been reviewed and it is evident that the ligature controls the vessels and is in no danger of slipping. After this the forceps is removed.

Step 4.—Make a careful and complete excision of the fatty capsule of the kidney. This is as important as excision of the axillary glands in removal of mammary cancer. The excision is made partly by blunt dissection, partly by cutting with scissors. All firm strands of tissue in which vessels may be hidden should be divided between ligatures or forceps. There must be no rough tearing. The location of the inferior vena cava should be borne in mind.

Gregoire thinks that the suprarenal body ought to be removed with the kidney in the presence of renal cancer.

Step 5.—With retractors expose to sight the whole retroperitoneal cavity. All hemorrhage is attended to and any tears which may have been made through the peritoneum are closed by suture.

Step 6.—Dry the cavity. Provide drainage either by means of gauze packing or by tube. Close the lumbar wound. Unless the wound is infected, the drainage may be dispensed with after two days.

If the tumor to be removed is very large, it is often wise to seize the pedicle and any adhesions with forceps and attend to the ligations after the tumor is out of the way.

Occasionally thrombi, malignant in character, are present in the renal vein and even in the inferior vena cava. Such thrombi should be removed even if it is necessary temporarily to clamp the vena cava itself. Israel is authority for this advice.

2. *Nephrectomy for non-malignant disease:* If the kidney is not too adherent (as a result of old inflammation) to its surroundings, the whole organ can be shelled out of its bed by finger dissection. A pedicle needle is passed between the vessels and the ureter as they enter or leave the hilus; a double ligature is pulled through as the needle is withdrawn. One ligature is tied tightly around the vessels as already described. The ligature intended for the ureter is not yet tied. The ureter is grasped by forceps. The pedicle is divided, leaving a sufficiently large stump, and the kidney is removed. The ureter is now examined. If it is clean and safe, the ligature provided for it may be tied and the ureter allowed to drop into the wound. If the ureter is infected and its cavity dilated and full of pus, it must be thoroughly cleansed both by washing and by scraping with a sharp spoon. After being cleaned, the ureter may be ligated and allowed to retract into the wound, or it may be left open and fixed to the lumbar wound by a few sutures. If the disease for which operation is performed is tuberculous and the ureter is involved, it may be followed, through the lumbar wound, down to the brim of the pelvis and excised to that extent. In any event an effort should be made to deprive the distal ureter of its mucous lining and to close the upper opening of the distal segment by inverting it. Mayo treats the ureter by injecting into it about a drachm of liquid carbolic acid. He finds this effective and harmless.

If in non-malignant disease the kidney is so firmly adherent to its surroundings as to make removal by the usual method a matter of great difficulty, then its fibrous capsule may be opened and the kidney proper separated from its capsule and removed, leaving the fibrous capsule *in situ*. The vessels when isolated are caught in a clamp which is left *in situ*. If the organ peels out without the vessels being isolated and clamped, pack the cavity lightly with gauze; as the surrounding scar tissue gives ample support to the packing this is thoroughly effective for purposes of hemostasis. Any diseased material adhering to the capsule is to be scraped away.

The excision of a very large hydronephrotic kidney calls for manœvures not yet considered. Israel says that observance of two rules makes the operation tolerably easy and safe. *First*, as in the case of all benign tumors, be sure to get down to the capsula propria. This is accomplished by cutting the tissues layer by layer, each layer being raised by two forceps before being cut and the cut being made between the forceps. It is surprising how many layers of more or less firm fibrous tissue are formed from the fatty capsule and must be passed before the capsula propria is reached. Having reached the capsule, clear as large an area of its surface as is possible without evacuating its contents. *Second*, a trocar and cannula are inserted into the tumor to empty it. The cannula is provided with a long rubber tube to drain away the fluid without soiling the wound. When the tumor has collapsed, withdraw the cannula, at the *same moment* closing its puncture wound by catching up a fold of the tumor-wall (at the point of puncture) between the finger and thumb. Forceps may be used instead of the digital grasp. Pull the now flaccid tumor-wall out of the lumbar wound, separating adhesions with the flat of the fingers of the other hand as the tumor is being delivered. Tough adhesions must be divided between ligatures or forceps. These will be most common near the top of the tumor. Do not

bore in or mine with the fingers around the tumor, and never endeavor to hook out the growth with the fingers. Such endeavors may tear the pedicle or even lacerate the vena cava. Everything must be done under control of the eye. When the sac is so far extracted that the region of the hilus is reached, even more care must be exercised in the separation of adhesions, as in hydronephrosis the veins are not always gathered together in a convenient pedicle, but are spread out and have many diverging branches. Operating in the above manner, every vessel may be seen and ligated.

(B) *Nephrectomy by the Abdominal Route.*—The kidney is exposed by Langenbuch's incision (page 632). The finger passed through the wound in the mesocolon separates the kidney from its surroundings until the hilus is reached. With an aneurysm needle a double ligature is passed between the ureter and the vessels, and *the vessels* are tied in two places and divided between the ligatures. This double ligation is practised to prevent a flow of blood from the kidney which would obscure the wound. The ureter is divided between forceps. The kidney is removed. The ureter is examined, and if found clean and healthy, it is ligated and allowed to retract into the wound. The whole retroperitoneal cavity created by the removal of the tumor is examined and any bleeding point which may have been overlooked receives attention. Oozing of blood is lessened by temporary pressure with gauze pads wrung out of hot water. Drainage may be provided through the lumbar region in the following manner: from the cavity to be drained a closed forceps is thrust backwards through the lumbar tissues, just external to the quadratus lumborum muscle, until it raises the skin on the back. The skin is incised and the point of the forceps thrust through the incision. If necessary, the opening may be enlarged. Either gauze or tubular drains may be employed, according to circumstances. The above operation appears easy *on paper*, but when the kidney is much enlarged and when it is adherent to its surroundings, the procedure is one of great difficulty. While the organ is being separated from its surroundings it may be necessary to apply many ligatures to control hemorrhage. A large cystic kidney may require to have its fluid contents aspirated before the pedicle can be treated or the tumor delivered. Of course, under such circumstances the puncture wound made by the aspirator or cannula must be closed with forceps as soon as the instrument is withdrawn. Treatment of the pedicle often presents difficulties. It may be easier to apply clamps to the vascular pedicle than ligatures. If this is done, much care must be exercised. Thornton once included a small piece of the vena cava in the forceps and lost his patient from hemorrhage. Hartmann, while enucleating a large pyonephrotic kidney, tore a hole of 3 cm. (1¼ inches) in the vena cava, below the renal vein. He immediately ligated the vena cava above and below; the patient recovered. Had the tear involved the region of the renal veins, he would have sutured the wound in the vena cava. Damar Harrison has done this successfully. When clamps are used, ligatures must be substituted for them as soon as the tumor is removed. Some surgeons, when possible, ligate the renal vessels before enucleating the kidney. When the ureter is septic, it must be doubly tied near the kidney and divided between the ligatures. The ligation prevents its septic contents escaping into the wound. The ureter (after the kidney is removed) is pulled outwards and fixed in the lumbar

drainage wound. Lumbar drainage having been provided, the abdominal wound can be completely closed. Many surgeons advocate careful suture of the wound made through the outer layer of the mesocolon so as to close the peritoneal cavity. This is generally considered unessential.

Remarks.—Exploration is indicated in cases where it is believed that the kidney has been ruptured and that extravasation of urine or blood is taking place. Any lacerations found must be closed by suture. If mere suturing is insufficient to stop the hemorrhage, or if the trauma has destroyed much renal parenchyma, the wound in the kidney should be packed with gauze held in place by plain catgut sutures (Fig. 798). The gauze should be surrounded by rubber tissue so as to avoid adhesion between it and the kidney tissues.

The happy results of non-intervention in cases of uncomplicated subcutaneous rupture of the kidney, reported by Alfred Frank from Körte's clinic ("Archiv für klin. Chir.," lxxxiii, 554), are such as to dampen operative enthusiasm. Körte never operates on uncomplicated cases of rupture of the kidney, no matter the extent of hemorrhage and hematoma. If infection is present operation must not be delayed.

Ransohoff promulgates the following theses regarding renal tuberculosis where operation is indicated: "(1) When the operation reveals a strictly localized lesion, a partial excision or curettage should be done.* (2) Nephrotomy is indicated when uncertainty exists as to the condition of the opposite kidney or for the temporary relief of an acute sepsis, and when the condition of the patient will not permit the major operation. It is then to be followed as speedily as possible by nephrectomy. (3) Unless unusual conditions call for nephrotomy, it is not to be advocated for renal tuberculosis. It may even do harm by autoinfection. (4) Primary nephrectomy should be considered the normal procedure for renal tuberculosis when an operation is at all indicated."

Liechtenstern ("German Urological Society," 1907) examined at intervals the urine of seventeen patients submitted to nephrectomy for tuberculosis. The examination was by inoculation of guinea-pigs. In seven the results were negative. In three the results were at first positive, later negative. In seven every examination showed bacilli. Voelker reviewed the late results of seventeen cases of operation for renal tuberculosis in the Heidelberg clinic (1902 to 1906). His conclusions were (*a*) the disease is less grave in the female; (*b*) in the patients who survive the operation the symptoms are late in disappearing (up to two years); (*c*) the mortality during the first six months after operation is 25 per cent.

The presence of a renal calculus always calls for operation. The danger of the condition and especially of the operation is not so much due directly to the stone as to infection. This seems a truism, but in renal and biliary surgery physicians and patients are far too prone to delay interference until such becomes distinctly, if not very, dangerous. The same reasons which make early operation safe in cases of appendicitis call for early operation in renal calculus, although in the latter a moderate amount of delay does not lead to such disastrous results.

Pyonephrosis or surgical kidney demands operation. If the disease is so

* The author has mistaken an apparently well-encapsulated hypernephroma for a localized tuberculous lesion, performed partial excision, and obtained a disastrous result. This error is easily made, and should be remembered.

severe that drainage will put too great strain on the patient's recuperative powers; if the other kidney is in such health that it can be depended upon for elimination, and if the immediate condition of the patient permits nephrectomy, then nephrectomy is the operation of choice. When doubt exists as to the functional ability of the other kidney, or when the general condition of the patient contraindicates the more severe operation, drainage is the operation of choice. The same is true in calculus disease when infection is present. If in the above disease the inflammatory process is moderate and a useful amount of renal parenchyma remains intact, drainage gives excellent results, or partial nephrectomy plus drainage may be the better procedure to adopt.

Anuria, especially calculus anuria, calls for nephrotomy, and, as Morris points out, the operation ought to be on the kidney which appears to have become last affected, *i.e.*, on the organ which presumably is in the better condition. Anuria following nephrectomy calls for immediate nephrotomy on the remaining kidney. (Willy Meyer.)

Harrison demonstrated long ago that operations undertaken for calculi proved in many instances curative, even when no calculi were found, and he concluded that nephrotomy might be a reliable therapeutic agent in certain cases of acute nephritis by relieving renal tension. A. H. Ferguson, Edebohls, and others believe that by decortication of the kidney a cure (symptomatic at least) may be obtained in chronic interstitial nephritis. At present this subject is distinctly *sub judice*, but very remarkable results have been claimed by thoroughly reliable men.

E. Martini ("Archiv für klin. Chir.," lxxviii, p. 619) experimented on dogs. At various periods after kidney decortication (even after many months) he killed the animals by bleeding; ligated the renal artery and vein and then injected colored gelatin through the aorta and ascending vena cava. By these means Martini was able to study the collateral circulation of the kidney. An abstract of his conclusions follows:

1. The new renal capsule is principally the result of growth of the interstitial connective tissue and of the endothelium of the vessels of the cortical zone of the cortex.

2. New capsule is firmly adherent to the kidney, is not of uniform thickness, but is thicker than the normal capsule. Its thickness is greater if the fatty capsule has been removed and nephropexy performed as well as decortication.

3. The new capsule shows no tendency to shrink or to sclerosis; it retains its normal structure and rich vascularity.

4. Decapsulation causes only temporary phenomena of hyperemia in the periphery of the kidney and no epithelial degeneration.

5. There is a temporary decrease in the secretion of urine from simple causes.

6. Ligation of the renal artery or vein causes more degeneration and necrosis in normal than in previously decapsulated kidneys.

7. The collateral circulation through the new capsule can fully compensate for the stoppage of outflow through the renal vein when it is ligated; it only partially takes the place of the renal artery when that is ligated.

8. Decapsulation and simultaneous ligation of the corresponding renal vein is fatal.

9. If both kidneys have been decapsulated and are provided with a new formed capsule, one renal vein may be ligated and a month later the other ligated also without death of the animal.

10. A dog can survive simultaneous ligation of the artery and vein of one kidney only when the fibrous capsule of that kidney has been previously extirpated.

11. The collateral circulation of a previously decapsulated kidney is sufficient to preserve the life of a dog when the other kidney is removed and the vein of the decapsulated kidney is ligated.

Congenital Cystic Kidney.—This disease is usually bilateral and is thought to kill because of the pressure exerted by the innumerable cysts upon the secreting tissues. If the growth and multiplication of the cysts could be stopped, then a practical cure might be attained.

Fred Lund (Journ. A. M. A., Sept. 26, 1914) has followed Rovsing in exposing the kidney in the loin, puncturing all the exposed cysts. A large part of the posterior surface of the kidney may be seen and the cysts punctured by proper retraction of the wound. As the cystic contents flow out, the kidney decreases in size and can be delivered and held in the hand. It is now easy to palpate large cysts and collections of cysts and to empty them with a hollow needle. In this manner a kidney which was from six to ten times the normal size may be reduced to twice the normal, returned to its bed and the wound closed without drainage. Both Rovsing and Lund have had a few gratifying results from this operation.

Bevan and McRae have each seen cases of unilateral polycystic kidneys.

Horse-shoe Kidney.—A. Martinow ("Zentralblatt für Chir.," 1910, No. 9) describes a case of horse-shoe kidney in which he operated with good effect. The report is so suggestive that it requires sonsideration and may aid the surgeon in locating a very limited class of obscure abdominal trouble. A nurse, aged forty-nine complained from child-hood of a disagreeable pulsating sensation in the whole abdomen; for many years there was severe pain above the umbilicus and marked obstipation. The pains increased and did not disappear at night. The patient became hysterical, and underwent treatment for hysteria during many years. Appetite poor; occasional vomiting; bowels moved every two or three days; marked peristalsis and abdominal pains. A tumor was palpable above the umbilicus. Aorta, tumor, and cæcum tender on pressure. Tumor occasionally increases in size when the pulsation of the aorta and other abdominal arteries becomes stronger and more annoying. No pain in the kidney regions. All other organs normal.

Diagnosis.—Tumor of pancreas or horse-shoe kidney. Laparotomy was performed. A tumor was found lying directly on the aorta; it was about 4 cm. wide and 2 cm. thick and formed an isthmus uniting the two kidneys lying one on each side of the vertebral column. The diagnosis of horse-shoe kidney was clear. Each half of the abnormal kidney was provided with a ureter.

After incision of the peritoneum overlying the tumor the isthmus was grasped with two intestinal clamps and divided. Immediately the two halves of the kidney retracted one from the other and the aorta was freed from pressure. After removal of the clamps from the kidney hemorrhage was easily controlled

by a few catgut sutures. The peritoneal wound was sutured and the abdomen closed without drainage. Martinow writes, "I would not assert that the isthmus should be divided in cases where horse-shoe kidney is discovered accidentally during an operation, but I do intimate that in cases with symptoms due to pressure on the sympathetic plexus this simple operation is possible and ought to be tried."

CHAPTER XLVIII

OPERATIONS ON THE URETER*

Anatomy.—The ureters conduct the urine from the kidneys to the base of the bladder, the walls of which they pierce obliquely, thus providing themselves with valvular outlets. The average length of the ureter is 12 inches; its narrowest point is about 2½ inches below the hilum of the kidney (diameter here about ⅛ inch), and the next narrowest point is at the brim of the pelvis. Calculi are liable to become caught at these two places and at the point where the bladder is entered. The ureters are lined by a thin mucosa which is thrown into folds. A thick muscular and a thin but elastic external fibrous tunic complete the ureteral wall.

The ureter lies loosely in the post-peritoneal connective tissue. "In the abdominal portion of its extent it lies upon the front of the psoas muscle, and about half-way between its commencement and the brim of the pelvis, or somewhere below that point, it crosses in front of the genito-crural nerve. The upper half of this portion of the duct, except at its commencement on the right side, where it is covered by a third part of the duodenum, is in direct contact with the peritoneum, to which it is intimately connected; and the lower half is separated from the peritoneum by the spermatic or ovarian vessels, which are, however, closely united both to the ureter and to the serous membrane. . . At the brim of the pelvis the relation of the ureter to the large vessels is not always quite the same, as it may rest either upon the lower end of the common iliac artery or upon the external iliac; it is covered in front by the peritoneum and it is crossed on the right side by the termination of the ileum, and on the left by the commencement of the rectum." (Morris, "Surgery of the Kidney and Ureter.")

Tourneur's point corresponds approximately to the upper end of the ureter and the level of origin of the spermatic or ovarian artery. Draw a transverse line from the tip of one twelfth rib to that of the other. Draw a vertical line upwards from the junction of the middle and inner thirds of Poupart's ligament. Where these two lines cross is Tourneur's point.

To find where the ureter crosses the iliac artery, Morris gives the following advice: For practical purposes, a point lying at the junction of the upper and middle thirds of the line indicating the course of the common and external iliac arteries will sufficiently indicate its position. The line marking the course

* In this chapter very free use has been made of Morris' work on "Surgical Diseases of the Ureter and Kidney."

of the iliac vessels is drawn from the bifurcation of the aorta, half an inch below and to the left of the umbilicus, to midway between the anterior superior spine of the ilium and the symphysis pubis.

Hydronephrosis is commonly the result of ureteral obstruction, whether due to calculus, stricture, external pressure, or torsion of the tube from renal ptosis. Of course, the cause must be sought and, if possible, removed.

FIG. 802.—(*Eckehorn.*)

FIG. 803.—(*Eckehorn.*)

Very frequently a branch from the renal artery, or even direct from the aorta enters the kidney at a point remote from the pelvis. The ureter may become kinked over this branch. The above is a common cause of hydronephrosis and ligation, and division of the aberrant vessel is usually the proper treatment.

A glance at Figs. 802, 803 and 804 shows diagrammatically the relations of the ureter to aberrant vessels, while Figs. 805, 806 and 810 show how the vessels may produce hydronephrosis.

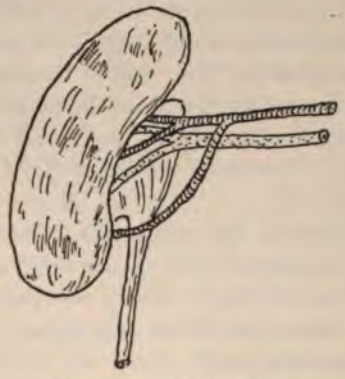


FIG. 804.—(*Eckehorn.*)

FIG. 805.—(*Bazy.*)

Bland Sutton believes that the kinking of the ureter over the abdominal vessel is the result, not the cause of the hydronephrosis. A number of reliable surgeons, however, find that the hydronephrosis is cured after division of the vessel apparently causing the kinking.

It is important to note the relationship between the ureter and the pelvis of the kidney. Normally the ureter opens into the lowest point in the pelvis, but in hydronephrosis the opening may be high up on the pelvic wall, and hence escape of fluid from the kidney becomes impossible even if the original obstruction of the ureter is remedied. Various operations have been devised for the correction of the faulty relation between ureter and renal pelvis.

Mynter's Method.—Expose and explore the kidney and its pelvis. Make an incision into and explore the interior of the greatly dilated pelvis or the hydronephrotic sac. If possible, pass a catheter through the ureter down to the bladder and find if ureteral stenosis exists. If the opening of the ureter is high up on the side of the sac (Fig. 807), make the incision A, B, through the wall of the sac, parallel and opposite to the ureter. Make the similar

FIG. 806.—(*Bazy.*)

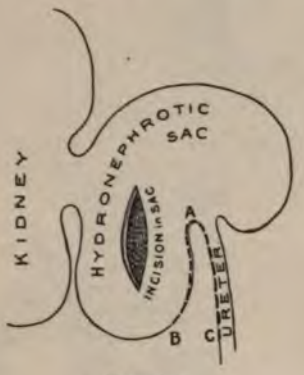


FIG. 807.

incision A, C, in the ureter. Unite the anterior edge of the ureteral wound to the anterior edge of the sac wound (x–x¹, Fig. 808). Unite the posterior edge of the ureteral wound to the corresponding edge of the sac wound (y–y¹). The sutures, of fine silk or hemp, must not include the mucosa in their bite. (This lest calculi form on them.) The result is a lowering of the ureteral orifice to the lowest point in the sac (Fig. 809.) The operation is identical in principle with Mikulicz's pyloroplasty. If a ureteral stricture exists between the points A and C, the operation of course cures that also. When obstruction is due to kinking of the ureter over one of the renal vessels, either make an anastomosis between the sac and the ureter below the obstruction (Fig. 810, x–y) or divide the ureter and unite the open end of the lower segment to the lowest point in the hydronephrotic sac.

Mayo's method of using a flap of fat to support the line of suture in the kidney pelvis is most valuable (see p. 653).

Küster ("Archiv f. klin. Chir.," xliv, 850) describes a case where the above operations were impracticable, as an impermeable stricture of the ureter existed a short distance below the sac. He divided the ureter immediately below the stricture, separated it sufficiently from its surroundings so that it could be brought up to the sac without tension, split the upper end of the ureter (Fig. 811), made an incision through the posterior wall of the sac at his lowest level, spread open the split upper end of the ureter and sutured it to the vivified internal

surface of the anterior wall of the sac (Fig. 812). The ureter was thus formed into a sort of funnel opening into the sac. The wound in the sac was closed with sutures (Fig. 813). The result was good. Israel has lessened the size of the distended pelvis by a plication of its walls similar to that practised for the cure

FIG. 808.

FIG. 809.

FIGS. 808 AND 809.—Mynter's operation.

FIG. 810.—(*Modified from Morris.*)

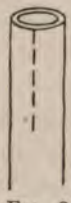


FIG. 811.

FIG. 812.

FIG. 813.

FIGS. 811, 812 AND 813.—Küster's operation.

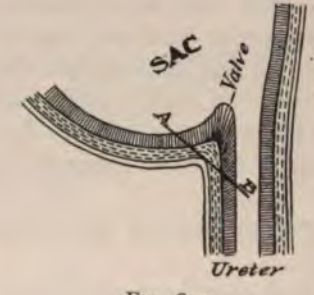


FIG. 814.

FIG. 815.

FIGS. 814 AND 815.—Fenger's operation.

of dilatation of the stomach. Occasionally in hydronephrosis a valve is present at the ureteropelvic junction, which prevents the complete evacuation of the renal pelvis or hydronephrotic sac. Fenger's operation for this condition is as follows: Expose the kidney. Open the renal pelvis and examine the interior,

especially the ureteral opening. Pass a bougie into the ureter. Excise the valve by a transverse incision (Fig. 814, A B). Close with fine catgut sutures the wound left by the incision of the valve. Close the wound in the sac.

When hydronephrosis is due to or kept up by a stricture at the junction of the ureter and pelvis, the operation practised by Fenger was the following: Make the incision A, a (Fig. 815), through the stricture and continue for a short distance upwards through the sac-wall and downwards through the ureteral wall. With sutures unite the points A, a; B, b; C, c, etc. This practically amounts to an anastomosis between the ureter and the renal pelvis. To avoid tension it may be necessary to separate the ureter from its surroundings for a short distance.

Exposure of the Ureter.—(A) *Transperitoneal Route.*—The ureter can be reached through a median or lateral abdominal incision. This method is valuable as a means of diagnosis, permitting, as it does, palpation of the opposite kidney, and the recognition of stones impacted in the ureter and of other conditions. When a stone is situated low down in the ureter it may be palpated through an incision through the rectus muscle or through a "gridiron" incision such as used in appendectomy, but placed a little more external than in the latter

FIG. 816.

FIG. 817.

Exposure of ureter. (*Monod and Vanverts.*)

operation. Guided by a finger in the abdomen, strip the peritoneum from the parietes on the outer side of the wound until the ureter and stone are exposed. Protect the wound in the peritoneum either by packing or by closing it. Incise the ureter extraperitoneally. Provide drainage through a separate incision. Morison has frequently operated in this fashion and has never infected the peritoneum. John Gibbon has had similar experience. In operations, such as uretero-ureterostomy and uretero-cystostomy, etc., the transperitoneal route is of great value.

(B) *Extraperitoneal Routes.*—I. *Lumbo-ilio-inguinal route* (Morris): By this route the ureter may be explored throughout its whole length. (*a*) Exploration of lumbar portion of ureter. Place the patient lying on his healthy side with the abdomen turned somewhat towards the table. Do *not* place any pillow under the opposite loin. Beginning at the outer edge of the sacro-lumbar mass of muscles, a little below the twelfth rib, make an incision obliquely forwards and downwards to a point 1 inch internal to the anterior superior spine of the ilium. Continue the incision parallel to and 1 inch above Poupart's ligament, as far as its centre (Figs. 816 and 817). *Cut down to, but not through,* the peritoneum.

Expose the kidney. Palpate the renal pelvis between finger and thumb. By exercising slight traction on the pelvis the ureter may be made more prominent. With the fingers or a pledget of gauze strip the peritoneum from the parietes until the ureter is seen. "The relation of the ureter to that part of the peritoneum which is adherent to the spine is rather constant, the ureter being situated just external to the line of adhesion. Therefore, when the operator has stripped up the peritoneum and reached this point, he will find the ureter on the stripped-up peritoneum external to it." (Kelly.) Remember that the ureter adheres to the peritoneum even when that membrane is raised from the subjacent structures. A little tension exercised on the renal pelvis helps to render the ureter recognizable.

FIG. 818.—(*Herrick, Cleveland Med. Jour.*)

(*b*) Exploration of pelvic portion of ureter. Roll the patient over so that while still resting on his sound side his back, instead of his abdomen, is turned somewhat towards the table. Enlarge the wound, if necessary, forwards, "even as far as the external abdominal ring" (Morris), always carefully avoiding opening the peritoneum. This huge wound may be avoided by seeking the pelvic ureter through a low "gridiron" incision which penetrates to, but not through, the peritoneum. Should the peritoneum be opened by accident, close it at once with sutures. Sometimes the kidney is not available as a guide to the ureter and one is forced to hunt for that tube at the pelvic brim. Here the guide to the ureter is the place where it crosses the iliac artery, and when the peritoneum is stripped off, it will be found adhering to that membrane "like a whitish or yellowish-white tape." In the male the ureter may be examined in

this manner down to the bladder, but in the female it runs in the broad ligament, which makes it very difficult of access. The uterine artery lies in front, the veins behind, the ureter.

Herrick's Method.—("Cleveland Med. Journ.," Dec., 1910.)

Step 1.—Draw an imaginary line from the inner lip of the anterior superior spine to a point above the opposite pubic spine. Beginning at a point 1½ to 2 inches from the anterior superior spine make an incision along the imaginary line for 3 to 3½ inches (Fig. 818). This terminates at the edge of the rectus "1 to 1½ inches above the entrance into it of the deep epigastric artery." Split the tendinous external oblique along the line of the incision. Split the internal oblique and transversalis parallel to their fibres and to the nerve trunks which lie between them. Do not open the peritoneum.

Step 2.—With the fingers dissect the peritoneum up from the side and the floor of the pelvis. A broad retractor placed at the lower end of the incision gives good access to the deep pelvis. Pass the finger to the bifurcation of the common iliac artery and turn the palm of the finger against the under surface of the peritoneum where it will feel the ureter closely adherent to the peritoneum covered by some of its reflected fibres.

Step 3.—Separate the ureter from the peritoneum for an inch or two, pass a tape around it and apply slight traction when the ureter will stand out like a ridge extending to the base of the bladder.

Step 4.—Remove any stone by incision. Close the cut with plain catgut sutures. *Never* use gauze for drainage. Close the abdominal wound.

Kidd's method (Lancet, June 7, 1913) is very like Herrick's. Trendelenburg's position. Three-inch incision parallel to and 1½ inches above Poupart's ligament. Two inches of the cut extend outwards and one inch extends inwards from the outer edge of the rectus. Split the aponeurosis of the external oblique the whole length of the wound. (N. B. The aponeurosis of the external and internal oblique muscles do not fuse to form the anterior sheath of the rectus until at least one inch inside the edge of that muscle.) Retract the edges of the wound and split the internal oblique and transversalis in the direction of their fibres for a distance of two inches external and one internal to the edge of the rectus. Retract the rectus inwards and observe the deep epigastric vessels as they pierce the transversalis fascia and dip in front of the semilunar fold of Douglas to enter the rectus sheath. Just external to and above the point where the deep epigastric vessels enter the rectus sheath tear through the transversalis fascia into the subperitoneal fat. Divide the transversalis fascia outwards the whole length of the wound. With the finger separate the peritoneum from the iliac fossa and side of the true pelvis. In the pelvic fossa note and retract downwards and inwards the vas deferens; retract upwards and outwards the spermatic vessels. In the female the ovarian vessels and round ligament are treated similarly. Guided by the external iliac artery find and clear the common and internal iliacs. The ureter crosses the pelvic brim over the external iliac artery and runs down the pelvic wall parallel to and just in front of the internal iliac. It is attached to the peritoneum. Strip the ureter from its bed for a distance of two or three inches above and below where it crosses the external iliac. Long narrow retractors are required to give good exposure.

Introduce into the ureter two sutures of the finest chromic catgut by means of fine needles as shown in Fig. 819. Put strips of gauze under the ureter to soak up escaping urine. Using the sutures as retractors make a very small incision in the ureter with a tenotome. (If the urine is very septic clamp the ureter above the incision with suitable rubber covered forceps.) Introduce a ureteral bougie and locate the stone. Remove the stone with ureteral forceps. Close the ureteral wound with fine catgut sutures and cover this with sutures in the periureteral tissues. There is usually no leakage and the wound heals by first intention. If necessary the ureter may be cleared all the way to the bladder. In the female this involves ligation of the uterine vessels. Introduce a slip of rubber tissue to the site of the ureteral wound as a drain. Close the wound in layers. One particular advantage claimed for the operation is that the ureter is generally opened remote from the site of the stone and hence in a healthier place so that there is less fear of subsequent stricture.

II. *The sacral route:* Morris thus describes Delbet's operation: "(1) The patient should be placed upon his sound side, so that the rectum may fall away from the wound. (2) The incision should be **L**-shaped, with the long arm vertical, along the border of the coccyx, and the short falling upon the superior extremity of the first, being almost parallel to the fibres of the gluteus maximus. (3) Cut the insertion of this muscle and the sacro-sciatic ligaments and some fibres of the pyriformis. (4) Lay bare the lateral face of the rectum with forceps and a director. The ureter is always to be found adherent to the detached peritoneum, and can be followed downwards to the bladder and upwards for seven or eight cm. from its termination. This description applies specially to man; in woman the operation is more difficult because of the broad ligament."

Various surgeons have used modifications of Kraske's sacral operation to gain access to the ureter, but these have little to recommend them.

(C) *Perineal Route.*—An operation through the perineum, very similar to that used for the exposure of the prostate by a curved transverse incision, permits the exposure of the seminal vesicles, and with them the lower end of the ureter.

(D, E) *Vaginal and Rectal Routes.*—Ureteral calculi palpated through the vagina or rectum have been successfully removed by direct incision through the walls of these cavities. The wounds were sutured immediately.

(F) *Transvesical Route.*—Calculi impacted at the vesical orifice of the ureter may be reached and removed by suprapubic or perineal cystotomy. Young and Bransford Lewis have successfully removed calculi in this position by means of the cystoscope.

Ureterotomy and Uretero-lithotomy.—Expose the ureter by one of the extraperitoneal methods. Introduce into it, if possible, two catgut sutures (x–x^1, y–y^1, Fig. 819), each of which is in the long axis of the ureter. Using the sutures to fix the tubes, make a longitudinal incision into the ureter, over the calculus, if such is present. It is wise, when possible, to push the stone up the ureter, incising at this new point lest ulceration at the site of impaction interfere with healing. Remove the calculus or explore the ureter as may be indicated. Apply a long strip of folded rubber tissue or oil-silk over the ureteral wound between the two sutures. Tie the end of the suture x over the rubber tissue to y,

and the end of the suture X^1, similarly to Y^1 (Fig. 820). Bring the free end of the rubber tissue or oil-silk out of the wound in the parietes. Close the parietal wound except where the drain emerges. This closes the ureteral wound efficiently and safely.

Many surgeons suture the wound in the ureter with a few fine silk or hemp stitches which do not involve the mucosa; other surgeons omit all suture of the ureteral wound, trusting to nature to close the wound, draining the wound with rubber tissue or tube. Simple through-and-through sutures of catgut are all that is necessary, but a drain of rubber tissue or oil-silk ought always to be attached to the line of suture. The use of gauze in connection with renal or ureteral wounds is liable to lead to the formation of fistulæ. When drainage of the ureter is desired, one may act as follows:

Trim, in the fish-tail fashion, the end of an appropriate sized rubber tube; wrap around the tube a few layers of gauze; cover the gauze with rubber tissue.

FIG. 819.

FIG. 820.

Ureterotomy.

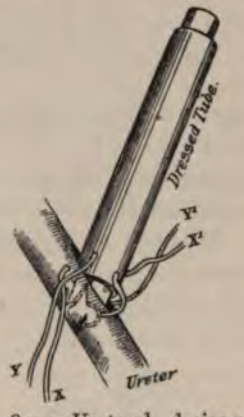


FIG. 821.—Ureteral drainage.

Leave about ¼ inch of the "fish-tail" end of the tube free from gauze. Perform the ureterotomy, using catgut sutures as handles (Fig. 819). Introduce the bared end of the dressed tube into, or over, the ureter (Fig. 821). Do not permit the gauze on the tube to be in contact with the ureter. With a needle stitch sutures X–X^1 and Y–Y^1 to the tube; this holds the drain in place.

Ureterotomy for the cure of ureteral stricture is performed as follows (Fenger's operation):

Expose the ureter by the extraperitoneal route. Make a longitudinal incision into the ureter immediately above the stricture; pass a suitable probe or bougie through the stricture; continue the vertical incision through the stricture and downwards until the wound below the site of stricture is equal in length to that above (Fig. 822). With sutures unite the point A to A^1, B to B^1, etc. (Fig. 823). The result is practically the formation of an anastomosis (Fig. 824) between the upper and lower segments of the tube. Close the external wound after providing for drainage.

Ureterectomy.—Ureterectomy may be carried out as a step in the operation of nephrectomy or as a secondary operation. The ureter is exposed ex-

traperitoneally by the lumbo-ilio-inguinal incision. It is not always necessary to make the external incision continuous throughout the whole length described on page 665. After the kidney is delivered or removed the ureter may be followed, by a burrowing dissection, down towards the pelvis, a forceps or stout probe passed down to the bottom of the wound to act as a guide, while a second incision is made through the parietes (Fig. 825). No

FIG. 822.

FIG. 823.

FIG. 824.

FIGS. 822, 823, AND 824.—Fenger's ureteroplasty.

special description of technic is required. Note that an apparently tuberculous ulceration of the vesical mucosa near the mouth of the ureter is not a contra-indication to nephrectomy and ureterectomy. When the diseased kidney and ureter are removed, the vesical lesion frequently recovers spontaneously.

Ureteral Anastomosis.—(A) *Monari's Method: Lateral Anastomosis.*—This operation is practically the same as lateral anastomosis of the intestine. Fig. 826 sufficiently explains the method, which is in every way inferior to the Van Hook operation.

FIG. 825.—Exposure of ureter.

FIG. 826.—Monari's ureteral anastomosis.

(B) *Van Hook's Operation: Lateral Implantation.*—Split the upper segment of ureter for a short distance. This is important, as it prevents stenosis at the orifice (Fig. 827). Ligate the upper end of the lower segment of ureter. Pass the fine catgut suture x y through the lower wall of the upper segment opposite the split described above (Fig. 827). Make a vertical incision into the lower segment immediately below the site of ligation. With round needles (either

straight or curved) pass the suture x y through the opening in the ureter and make its ends emerge at the points o. n. (Fig. 828.) As catgut is not easily threaded in fine needles, one may arm the needles with a suture carrier of silk or hemp, by which means the introduction of the catgut becomes easy (Fig. 829). Insert the lower end of the upper segment of ureter through the wound in the lower segment, pull the suture x y sufficiently tight, and tie it (Fig. 830).

Whenever possible, the extraperitoneal route should be chosen in performing uretero-ureterostomy.

Uretero-cystostomy.—This operation is called for in certain cases of persistent ureteral fistula, in cases where part of the ureter has been destroyed in the course of operations, *e.g.*, on the uterus. It takes the place of removal of the corresponding kidney, and where feasible is the operation of choice.

FIG. 827.—Van Hook's operation.

(A) *Vaginal Route.*—When done to cure a uretero-vaginal fistula, the operation consists essentially in freeing the lower end of the ureter from its surroundings and in suturing it into a small opening in the bladder. When freeing the ureter, a bougie or probe passed into it is a most valuable aid. The method of uniting the duct to the bladder will be described in the succeeding pages.

(B) *Superior Extraperitoneal Route.*—Expose the ureter by the lumbo-ilio-inguinal incision or a modification thereof. This is much less difficult to accom-

FIG. 828.—Van Hook's ureteral anastomosis.

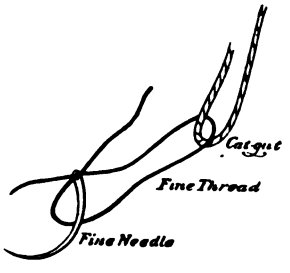


FIG. 829.

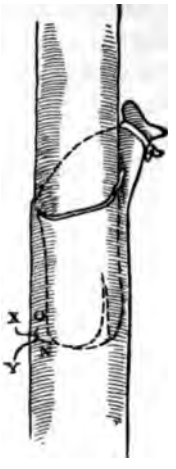


FIG. 830.—Van Hook's ureteral anastomosis.

plish in the male than in the female, so far as the pelvic segment of the ureter is concerned; the broad ligament interferes considerably in the female.

(C) *Transperitoneal Route with Extraperitoneal Ureterocystostomy* (Witzel's operation).—Open the abdomen by a median incision in the hypogastrium. Incise the peritoneum over the iliac vessels, separate the peritoneum from the subjacent structures by blunt dissection. The ureter will be found united to the peritoneum and elevated with it. Make slight upward traction on

the ureter to make it prominent and recognizable low down, in the broad ligament. By a second incision in the broad ligament expose the ureter; divide it; ligate and cauterize the opening in the lower segment. Pull the upper segment up to and out of the original incision over the iliac vessels. With a long forceps guided behind the peritoneum to the side of the vesical region "above the linea innominata," through this tunnel under the peritoneum, draw the ureter down, and anastomose it to the bladder extraperitoneally. Close the two small wounds in the peritoneum. To make the anastomosis without tension on the line of suture Witzel pulled the bladder towards the ureter and fixed it there, to the posterior parietes at the line of the peritoneal incision.

(D) *Intraperitoneal Route.*—This method has been used successfully in a number of cases and seems to be the method of choice when ureterocystostomy is undertaken in the course of an abdominal operation in which the ureter has been divided. The end of the upper segment of the ureter must be found, if necessary, in the manner described in Witzel's operation, and sufficient of it separated from its surroundings to permit its approximation to the bladder, without tension. To aid in this approximation Witzel's plan of suturing the bladder to the side of the pelvis may be useful, but Kelly's procedure is better. Kelly detaches the bladder from the horizontal rami of the pubes and thus can bring the bladder to the ureter. The dissection of the ureter ought not to be too "clean" lest nutrition be threatened and necrosis result.

Methods of Uniting the Ureter to the Bladder.—(A) Pass a forceps through the urethra into the bladder and push its point against the bladder-wall at the place where it is desired to make the anastomosis. At this point incise the bladder. The ureter has already been prepared and has a long suture penetrating its wall. Catch the ends of this suture in the forceps and pull them into the bladder and out through the urethra (in the male the urethra may be opened in the perineum for the passage of the forceps; in the female, the urethra serves). Traction on the suture pulls the open end of the ureter into the bladder and keeps it there temporarily. To prevent contraction of the open end of the urethra either cut it obliquely or split it as in the Van Hook operation for anastomosis. Carefully suture, with several tiers of suture, the outer coats of the bladder to the outer coats of the ureter in the Lembert fashion.

(B) This method is similar to the above, but a ureteral catheter is used in place of the forceps. Pass a ureteral catheter through the urethra into the bladder and bring its end out through an incision in the bladder at the site of anastomosis. Introduce the end of the catheter into the end of the ureter and tie it there with a fine plain catgut ligature (Fig. 831). Aided by traction on the catheter pull the end of the ureter into the bladder and fix it there by several layers of sutures introduced after the Lembert fashion. The ureteral catheter serves to drain the ureter and hold it in position until union takes place.

(C) *Van Hook Method.*—The end of the ureter is split to prevent subsequent stenosis. The operation is practically the same as in the case of uretero-ure-

terostomy, except that a line of Lembert sutures, burying the site of anastomosis and the one stitch which penetrates all the coats of the bladder, adds much security (Figs. 832, 833).

Implantation of the ureter into the intestine, preferably into the sigmoid, is carried out in the same fashion as into the bladder, but the results have uniformly proved disastrous, as infection invariably passes up the duct to the kid-

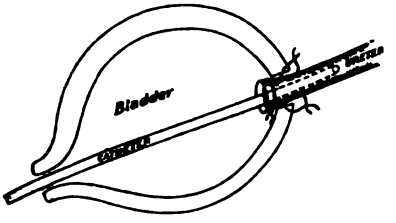


FIG. 831.

FIG 832.

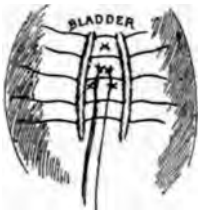


FIG. 833.

FIGS. 831, 832 AND 833.—Uretero-cystostomy.

ney. This disaster may be avoided by using Harold Stiles valvular implantation (p. 725) von Maydl's implantation of the ureters, plus a portion of adjacent bladder-wall, into the sigmoid does not belong to the same category and gives good results. It will be described in another chapter.

Union of the ureter to the skin is occasionally necessary, but the results are bad. Infection gains access to the tube and so to the kidney. The operation has its field of usefulness, however. When operating, *e.g.*, on a cancerous uterus, the ureter may be accidentally or intentionally divided; the condition of the patient may not admit of uretero-ureterostomy or uretero-cystostomy. Under such circumstances it may be the best policy to fix the ureter to the skin and subsequently perform uretero-cystostomy.

It has been suggested that in all cases of ureteral anastomosis success is promoted if the corresponding kidney is exposed posteriorly, fixed to the lumbar region, and drained through a nephrotomy wound.

CHAPTER XLIX

OPERATIONS ON THE BLADDER

ECTOPIA VESICÆ (EXSTROPHY OF BLADDER)

Exstrophy of the bladder may be complete or incomplete. When incomplete, the case is usually one of non-obliterated urachus, and urine escapes from the umbilicus. This may be due to some mechanical obstacle to normal urination, and treatment must be directed primarily to removal of such obstacle (*e.g.*, phimosis). If spontaneous closure of the fistula at the umbilicus does not occur, the passage may be obliterated by application of the cautery or by excision.

Complete exstrophy of the bladder is a condition in which the anterior vesical wall and a corresponding portion of the parietes are absent. The anterior surface of the posterior vesical wall pouts forwards and the urine escapes at once as it leaves the ureters. As a part of the maldevelopment, one

finds the pubic bones ununited and the penis in a condition of epispadias. Operations for the relief of ectopia vesicæ may be divided into five classes:

I. The formation of an anterior wall to the bladder by means of cutaneous flaps, the epidermal side being turned inwards to provide an epithelial lining for the viscus.

II. Union of the edges of the defect, thus providing a small cavity, but one lined by the bladder mucosa.

III. Formation of an anterior wall to the bladder from a segregated loop of intestine, thus providing a mucous instead of an epidermal lining.

IV. Excision of all the exposed bladder and transplantation of the ureters into the penile gutter.

V. Transplantation of the ureters into the intestine and excision of the bladder.

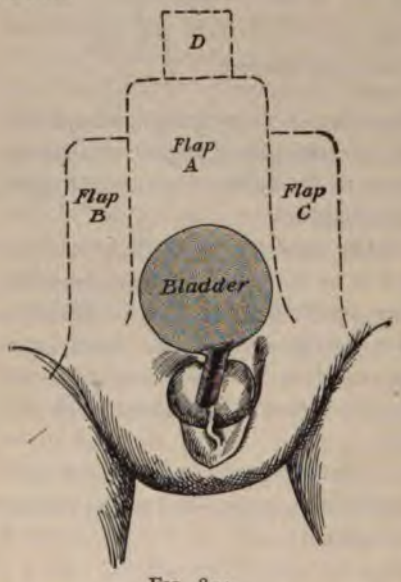


FIG. 834.

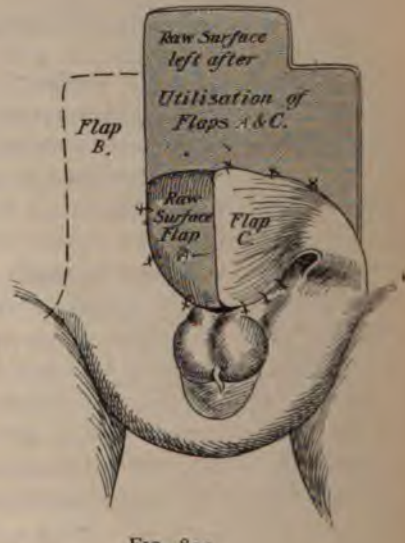


FIG. 835.

FIGS. 834 AND 835.—Wood's operation.

I. Wood's Operation for Ectopia Vesicæ.—Object of operation is to provide an anterior wall to the bladder and that such wall be lined with epithelium.

The Operation.—Flap A (Fig. 834) is made from the skin of the abdomen above the ectopic bladder and has its base near the bladder. In dissecting the flap from the subjacent tissues care must be taken to stop the dissection *at least* ¼ inch away from the edge of the bladder—*i.e.*, the hinge of flap A should be at least ¼ inch distant from the defect to be covered. The size of flap A should be greater than the defect to be covered. This is to allow for the shrinkage which always takes place in the flap. If it is desired to cover the dorsum of the penile groove with the same flap, then flap A may be extended upwards (the portion D of flap A D being used for this purpose). (Greig Smith.) Flaps B and C are obtained from the skin of the abdominal wall to the side of the bladder and of flap A.

The margins of the bladder are freshened by dissection except along the edge opposite the hinge of flap A, and where the penile groove or gutter enters the

bladder. Flap A is turned downwards, the line being the hinge or line of turning, so that the epithelial surface faces the bladder and the raw surface is external. The edge of the flap is stitched to the freshened edge of the bladder. Special care must be taken in suturing the lateral margins near the base of the flap, otherwise union does not take place. Flap C is dissected from the subjacent tissues and slid over the raw surface of flap A on one side (Fig. 835). The same is done with flap B. Both are sutured in position. The extensive raw surface left on the abdominal wall by the removal of flaps A, B, and C is diminished by sliding inwards the surrounding skin, and the remainder is covered by Thiersch's skin-grafts. If the extension D of flap A has been provided, then its edges are stitched to a line of freshening on each side of the penile gutter.

II. Trendelenburg's Operation.—Note, in cases of exstrophy, the pubic bones are not united at the symphysis. This want of union prevents immediate closure of the defect in the bladder and urethra. Trendelenburg overcomes the above difficulty as follows:

Make an incision about three inches in length over each sacro-iliac synchondrosis. Open these joints and divide their ligaments and the interarticular cartilages. Press the anterior superior iliac spines together, so that the pubic defect is obliterated or lessened. Suture and dress the sacro-iliac wounds. Keep the pubic bones in apposition by means of suitable binders applied to the anterior borders of the pelvis. After the wounds have thoroughly healed, the exposed surface of the bladder may be seen lying at the bottom of a more or less vertical groove, and may now have its edges freshened, mobilized, and united by sutures in the middle line.

This operation has given some excellent results.

J. W. Perkins, finding division of the sacro-iliac synchondrosis too difficult and dangerous, divided the ilium close to the synchondrosis with the chisel and obtained the same result.

Trendelenburg informs the author that he has used this method of osteotomy but considers it more hazardous than his original procedure. (For much information as to the treatment of exstrophy, see Trendelenburg's paper in "Annals of Surgery," August, 1906.)

Schlange's Operation.—Schlange makes an incision along the outer edge of the lower part of each rectus muscle and loosens the muscle from its surroundings. He then, with chisel and mallet, divides the bony insertion of the muscle from the rest of the pubis and slides the mobilized insertion towards the middle line, where he fixes it. The mobilization of the recti muscles permits of the approximation of the edges of the bladder and their union after freshening.

König ("Lehrbuch," ii, 634) has twice endeavored to close the pubic and vesical defects by one operation. He says: "I divided the horizontal and descending rami of the pubis through a small wound over the obturator foramen. This permitted closure of the defect in the symphysis when pressure was exerted on the pubis. The margins of the bladder and of the urethral groove were now freshened and sutured by two lines of stitches. Unfortunately, both patients succumbed." The principle of König's procedure seems admirable and its danger does not appear to the author to be intrinsically greater than that of some of the other methods the ultimate results of which are by no means brilliant.

Segond's Operation.—*Step* 1.—Make the incisions AB, DC, BC, around the ectopic bladder. The points A and D must not be at a lower level than the mouths of the ureters. Freshen the edges of the penile groove, E and F (Fig. 836).

FIG. 836.—Exstrophy of bladder.

Step 2.—Dissect the ectopic bladder downwards as a flap. The dissection must not be carried below the level of the ureteral mouths.

Step 3.—Turn the bladder flap downwards and suture its edges to the corresponding sides of the penile groove (Fig. 837).

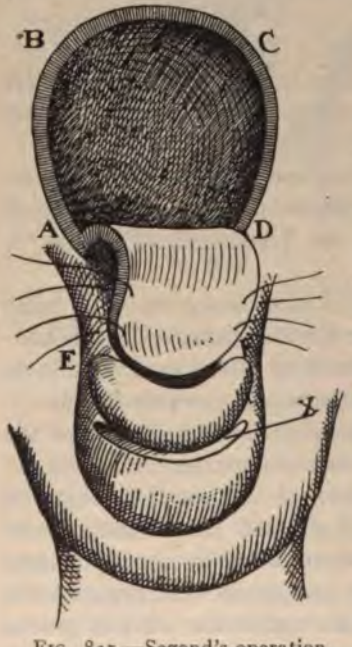


FIG. 837.—Segond's operation. (*Farabeuf.*)

Step 4.—Make a transverse incision through the base of the malformed foreskin (Fig. 837, X). By making the glans penis pass through the hole in the foreskin the latter is brought on to the dorsum of the penis and its tissue can be used to cover the raw surface on the back of the new-formed dorsum of the penis.

III. Rutkowski's Operation.—Rutkowski's operation and the similar one of Mikulicz have been used with more or less success in the treatment of exstrophy. They will be found sufficiently described in the pages devoted to repair of defects in the bladder-wall.

IV. Sonnenburg, in a case in which the exposed vesical mucosa protruded greatly, and in which no urinal could be used, operated in the following manner: Make an incision all around the exposed mucous membrane, and through this cut dissect the mucosa from the abdominal parietes, but do *not* injure the peritoneum. Remove the mucosa completely. Dissect the lower ends of the ureters from the surrounding structures sufficiently to permit their implantation into the upper end of the gutter,

which represents the urethra, and fix them there with sutures. Close the defect left in the abdominal wall by flaps slid over from its sides.

V. Maydl's Operation.—Excise all the exposed vesical mucosa except that portion immediately around the orifices of the ureters (Fig. 838). Carefully cleanse the wound and field of operation after the excision of the filthy mucous membrane. Open the abdomen. Find the sigmoid and bring a loop of it out of the wound. By stripping, empty the gut of its contents. Apply an intestinal clamp or tape above and below the part selected for anastomosis. Incise the gut longitudinally. With through-and-through sutures unite the edges of the portion of bladder-wall attached to the ureters to the edges of the wound in the sigmoid (Figs. 839 and 840). Cover this line of suture by a line of continuous Lembert sutures. The result is that the remnant or ellipse of

FIG. 838.

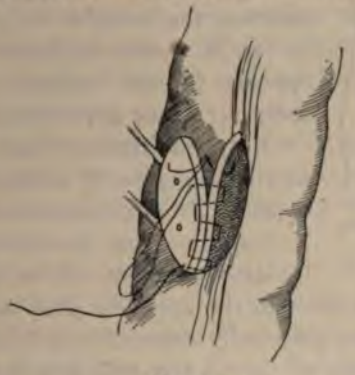


FIG. 839.

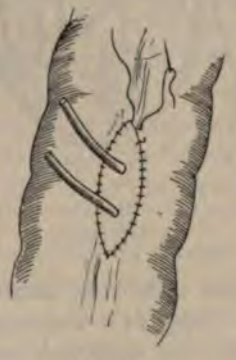


FIG. 840.

FIGS. 838, 839 AND 840.—Maydl's operation.

bladder-wall is inserted like a patch into the incision in the sigmoid. Note that no great separation of the lower ends of the ureters from their surroundings is required; the loop of sigmoid is brought down to the ureteral portion of bladder, which is, of course, mobilized. The implantation of the segment of bladder-wall containing the ureters, instead of the implantation of the ureters themselves, is the important principle in the operation; by it the normal ureteral valves or sphincters are retained and infection is prevented from ascending the ureters. Several modifications of Maydl's operation have been suggested, but most of them merely complicate the technic.

VI. Makkas' Operation.—("Zentralblatt für Chir.," 1910, No. 33.) To avoid the dangers of ascending infection inseparable from any method by which the ureters are made to discharge into a cavity containing fæces, Makkas excludes the cæcum from the rest of the intestinal tract, unites its cavity to the skin by means of appendicostomy and at a later date implants the ureters into the segregated cæcum using the appendix as a vent for the escape of the urine.

The Operation.—*Stage I.*—*Step* 1.—Open the abdomen by an incision through the right rectus muscle.

Step 2.—Examine the cæcum. If the cæcum cannot be pulled to the middle line, mobilize it by incising the parietal peritoneum parallel and close to its outer side.

Separate the cæcum by blunt dissection from its posterior connections exactly as in cæcectomy but carefully preserve intact its blood supply.

Step 3.—Divide the ileum close to the cæcum and close both the distal and proximal segments of the gut, Fig. 841.

Step 4.—Divide the ascending colon above the cæcum and close both the proximal and distal segments of the colon.

Step 5.—Make a lateralanastomosis between the proximal segment of ileum and the distal segment of the colon (or the sigmoid).

FIG. 841.—Makkas' operation. (*Makkas.*)

Step 6.—Perform appendicostomy bringing the appendix out through a special opening. (Bringing the appendix out through an opening made by splitting the muscles of the abdominal wall as in the McArthur-McBurney operation would, it appears to the author, provide an excellent sphincter to the appendix.)

If appendicostomy seems inadvisable or impossible because of adhesions, small size of the appendix, etc., perform cæcostomy.

Step 7.—Close the abdomen.

After-treatment.—After the lapse of ten days pass a Nélaton catheter through the appendix daily and irrigate the cæcum.

Stage II.—This stage is practically identical with the Maydl operation except that the mobilized portion of the bladder-wall attached to the ureters is implanted into the lower part of the segregated cæcum instead of into the sigmoid. When the operation is completed the new bladder must be kept empty by a catheter introduced through the appendix.

In Makkas' case the catheter was clamped after eight days and the new bladder emptied every two or three hours. At first the capacity of the bladder was only 100 c.c. After four weeks the capacity increased to 300–325 c.c. and the bladder required to be evacuated every three or four hours through the day but not at all during the night.

If the catheter was removed while the bladder was full there was no escape of urine, but this continence was not absolute as drops of urine escaped when the patient moved about. The urine was not albuminous but contained mucus. The necessity of leaving the catheter *in situ* permanently is a disadvantage, the lessening of the dangers of ascending infection is a great advantage over the Maydl method.

Geo. A. Peters' Operation (Brit. Med. Jour., June 22, 1901).—*Step* 1.—Cut the point off a No. 5 soft rubber catheter so that urine can enter its end. Pass it about 2 inches up the ureter. Fix the catheter by a few fine sutures caught through the extreme end of the ureteral papilla. Treat the other ureter similarly.

Step 2.—Make a cut through the bladder wall (mucosa and musculosa) around each ureteral orifice at a sufficient distance to leave intact the peculiar oblique arrangement of the vesical end of the ureter. As soon as the entire thickness of the bladder wall has been penetrated, mobilize the lower end of the ureters by blunt dissection.

Step 3.—Excise all the bladder down to the prostate where the vesiculæ seminales debouche. If there is danger of injuring the peritoneum at any place then at that point some of the bladder muscle may be left but all the mucosa must be removed.

Step 4.—Working through the wound expose the lateral aspects of the rectum.

Step 5.—With finger in rectum choose the exact point for ureteral implantation, which must be above the internal sphincter, on the lateral (not the anterior) wall so as to avoid kinking, and high enough to permit the ureter to project ¼ to ½ inch into the bowel, so as to form a valvular papilla. At the chosen point press the point of a forceps from the rectum towards the wound, and incise the gut wall upon the projecting forceps. The hole made in the rectal wall must be of such size as to hold snugly, but not too snugly, the ureter with its contained catheter. Pull the catheter and ureter into the rectum. The ureter must project without tension, not less than ¼ inch into the lumen of the bowel. The operation is the same on both sides.

Leave the catheters *in situ* at least two or three days or until they come away of themselves. Do not try to close the wound left by the ablation of the bladder. If the wound is fairly firmly packed with gauze, support is given to the ureters in their new position.

Remarks.—Peters' operation avoids all dangers of peritonitis as the peritoneum is never penetrated. The results have been excellent in the cases reported by Peters and by Holman (Brit. Med. Jour., Jan. 31, 1920). Holman agrees with Mayo that it might be wise to allow an interval of some weeks to elapse between the transplantation of each ureter.

Cunéo's Operation.—("La Presse Med.," Jan. 10, 1912.) Open the abdomen. Choose a suitable segment of ileum and segregate it by dividing the gut at two places. Restore the continuity of the ileum by enterorrhaphy. Close the proximal end of the segregated segment. Low down on the anterior surface of the rectum make an incision through the rectal wall leaving the mucosa intact. From this incision make a tunnel passing between the mucosa and the anal sphincter to the skin. Push the open end of the segregated segment of ileum through the tunnel and suture it to the skin. After healing has taken place, implant the ureters with the trigone of the bladder into the segregated intestine. Cunéo's patient could retain urine for two hours during the day but was incontinent at night. The urine was normal.

Heitz-Hovelacque Operation.—This operation is identical in principle with Cunéo's and gives almost identical results. Open the abdomen. Divide the rectum at the level of the second or third sacral vertebra. Close the distal segment of gut. This forms the new bladder. Bring the proximal segment of gut downwards behind the new bladder separating the latter sufficiently from the sacrum. Implant the ureters in the new bladder. Make an incision through the musculature of the back of the new bladder and form a tunnel to the skin between the mucosa and the anal sphincter. Pull the mobilized upper segment of rectum (or pelvic colon) through the tunnel and suture it to the skin. The result of this operation was almost identical with that of Cunéo. It is *said* that there was no escape of gas or fæces during urination.

Remarks.—The great objection to all operations which endeavor to reconstruct the bladder, whether by the use of skin-flaps, by the union of the edges of the imperfect viscus, or by the implantation of a segregated loop of intestine, is that the result is merely the formation of a urinary receptacle which is devoid of any sphincter and hence cannot retain the urine. The only advantages to be obtained by such operations are the protection of the vesical mucosa from injury and the direction of the urine towards the penile gutter, where it is more feasible to attach a portable urinal. The operation of excision of the imperfect bladder and transplantation of the ureters into the penile gutter possesses both these advantages, and is perhaps a better procedure than any of those which seek to reconstruct the bladder. In performing plastic operations such as those described it is very difficult to obtain complete union of the transplanted flaps to their surroundings—hence fistulæ occur which, unless closed, nullify the operation. One very grave objection to the plastic operations which provide the new bladder with an epidermal lining is that urinary salts are inevitably deposited on the bladder-walls and cause much distress. No matter how carefully the flaps have been selected, fine hair is liable to grow on them and give rise to complications. *Prima facie*, one would think that when the new bladder is lined with true mucous membrane, as in Rutkowski's operation, the danger from calculus deposits would be obviated, but experience shows this not to be true; hence the same objection obtains.

When simple uretero-sigmoidostomy or uretero-colostomy is performed, infection inevitably passes up the ureters and leads to a fatal issue. Stiles valvular implantation of the ureters (p. 725) seems to avoid this danger. Maydl's idea that transplantation of the ureters, plus their sphincteric attachment to the bladder-walls, avoids the danger of infection ascending from the gut seems correct. Peters' operation seems to have the advantages without the dangers and difficulties of Maydl's and is probably preferable. The lower gut is, or becomes very tolerant to the presence of urine, and the anal sphincter is capable of retaining the urine for a very respectable length of time.

Operative Treatment of Rupture of the Bladder.—The diagnosis of rupture of the bladder from the symptoms alone is not always possible before it is too late to be of aid in treatment. Other or operative means of diagnosis are often essential.

Diagnosis by Operation.—When the patient has overcome initial shock (twelve to twenty-four hours), or immediately if his condition warrants, diagnosis by operation may be attempted.

I. Injection of air or water into the viscus. By injecting air or water into the bladder, should the viscus be ruptured, no globular tumor will form over the pubis, and when the water is allowed to flow back, much less will return than was injected. Should there be no rupture, the distended bladder will be easily found in its normal site.

The above operation has often served a good purpose, but Schlange points out that the water or air introduced under pressure is liable to cause separation of peritoneum from the bladder along a ragged rupture—quite a serious objection. The same objection holds good against cystoscopic examination. Another objection which might be urged is that in the case of an extraperitoneal

ruptûre the air or water might easily distend the bladder to its normal limits and so lead to mistake.

II. Several surgeons have recommended perineal section and examination of the bladder through the wound. This has but few advantages over the next method, and is possessed of many disadvantages.

III. Suprapubic cystotomy. Without the aid of rectal distention the surgeon cuts into the bladder above the pubis. Under the special circumstances (empty bladder, etc.) much care must be taken to "hug" the pubis. The bladder having been opened, the finger soon discovers any ruptures of its wall.

If intraperitoneal rupture is present, the skin-wound is enlarged upwards and the belly opened. Any bloody urine in the peritoneal cavity is gently sponged away. It may now be necessary to put the patient in the Trendelenburg position. The ragged wound of the bladder is examined, and if necessary, some of its bruised edges trimmed away. A line of chromicized catgut sutures is put in place. These sutures pass through all the coats of the viscus except the mucosa. A line of Lembert sutures is inserted superficially to protect the deep ones. The abdominal cavity is now cleaned, either by flushing with normal salt solution or by gently sponging with gauze pads. The laparotomy wound is closed with or without drainage.

In extraperitoneal rupture the danger is, of course, from infiltration of urine. The suprapubic cystotomy guides the surgeon to the threatened or affected regions and he can at once provide free drainage by appropriate incisions and by packing such regions with iodoform gauze. Bleeding must be stopped either by ligature, pressure, or packing.

How ought the suprapubic wound of the bladder to be treated? In such cases it ought always to be left open. Schlange unites the vesical mucous membrane to the skin by a few stitches. The bladder itself is lightly filled with iodoform gauze, so that it is constantly emptied of urine by capillary drainage. Permanent catheterization of the ureters and packing of the bladder is a tempting procedure which would be liable to lead to ureteritis and pyelitis.

Suprapubic Cystotomy.—The operation of suprapubic cystotomy may be required for the removal of calculi or neoplasms from the bladder, for the removal of enlarged lobes of the prostate, for purposes of exploration and the treatment of various vesical lesions, and for the carrying out of retrograde catheterization, etc. Preliminary treatment varies according to circumstances —in one case, *e.g.*, prostatectomy, it is wise to endeavor to cleanse the bladder by appropriate means; in another case, *e.g.*, bleeding villous tumors, such treatment is calculated to encourage serious hemorrhage; in cases of cystitis where treatment *per urethram* is a failure, the cystotomy is undertaken to provide drainage, and the failure of other treatment means failure to cleanse the bladder. In all cases the large intestine should be well emptied before operation. Local or general anæsthesia is requisite.

Shave the pubis and cleanse the hypogastrium and the penis. Introduce a catheter and irrigate the bladder with warm salt, boracic acid, or Thiersch's solution. When the irrigation is finished, distend the viscus with the solution or with air. Remember that in cases of old cystitis the bladder-wall is often very weak and cannot safely be greatly distended. A good plan is to test the

capacity of the bladder before any anæsthetic is administered and act according to the knowledge gained. Many surgeons prefer air distention to fluid. Air is said to bring the viscus more easily against the abdominal wall, and when the bladder is opened, there is no gush of infected fluid over the field of operation. These advantages are of no great value and most surgeons prefer the warm aqueous solutions, which are more easily sterilized and managed than is the air. Air distention has led to several catastrophies. Having distended the bladder within the limits of safety, withdraw or plug the proximal end of the catheter and tie a rubber band around the penis to prevent the escape of the water or air. If the catheter is left *in situ*, it acts as a guide to the bladder.

Some surgeons endeavor to lift the bladder still more against the belly-wall by inserting a rubber bag into the rectum and distending it with air or water. This procedure is unnecessary and has led to many serious injuries being inflicted on the rectum. Even distention of the bladder itself is not *absolutely* necessary, but when possible, is always of immense value, as it pushes the vesical fold of peritoneum upwards and makes the extraperitoneal exposure of the bladder easy.

Place the patient in the Trendelenburg position, as this enlarges the extraperitoneal area through which one must proceed.

I. *Vertical Incision.*—Beginning on the pubis near its upper edge, make a vertical median incision upwards for from 3 to 4 inches. Expose and divide the anterior layer of deep fascia and separate the pyriform and recti muscles. Carefully pick up and divide the deep layer of fascia, thus exposing the prevesical fat. Hook the finger behind the pubis and pull upwards the prevesical fat, and with it the vesical fold of peritoneum. Recognize the peritoneal fold and retract it upwards out of danger. Rarely the peritoneal fold may be adherent to the pubis and must be freed by blunt or sharp dissection. During the manœuvres described the peritoneal cavity may be accidentally opened. This accident is only important if not promptly recognized and corrected by a few carefully placed sutures. Expose the anterior wall of the bladder by bluntly dissecting through the fat in front of it. Once the peritoneal fold is recognized and retracted, do not hug the posterior surface of the pubis too closely, as to do so means exposure of the bladder at a level difficult of access and where it is very vascular; it also means the formation of a ragged pouch difficult to drain, in very unresisting tissues. The nearer its dome the bladder can be exposed extraperitoneally, the better. The bladder will be recognized by its globular form, if distended, or by the catheter in it if it is not distended. It has a brownish-red color, and one can see the longitudinal fibres of the detrusor muscle on its surface.

The bladder having been *freely* exposed, pick up a portion of its wall with a sharp hook or volsella, and with a strongly curved needle pass two long sutures through its walls parallel to the direction in which it is desired to incise the bladder. These sutures serve as convenient tractors. Jacobson omits their use, as he thinks they do more damage than forceps attached to the edges of the incision. The writer has never seen harm result from the thread tractor, and they are certainly much more convenient than forceps, which always impede further operative work. Incise the bladder, either vertically or trans-

versely, sufficiently to admit one or two fingers. The transverse incision is the better; it is more readily enlarged and more readily closed. If the vertical incision is chosen and requires enlargement, such enlargement must be done downwards in an awkward location, deeply behind the pubis. If for the purposes of the subsequent steps of the operation (removal of calculi, tumors, etc.) the wound in the parietes is found too narrow, more space may be obtained by making a number of small incisions or nicks in the edges of the recti muscles, or those muscles may be separated from their pubic insertion. More room has also been obtained by subperiosteal excision of part of the pubic bones. Such extreme measures to gain space are rarely necessary.

The treatment of the various lesions met with in the bladder will be discussed later.

Treatment of the Wound in the Bladder.—If the bladder is not seriously infected or the wound has not been greatly contused, *e.g.*, by the removal of stones, etc., the opening may be closed in whole or in part. If marked vesical infection is present, or if the walls are much contused, it may be necessary or judicious to leave the wound wide open.

Closure of the Vesical Wound.—If the mucosa is inclined to bleed, unite the edges of the wound in it by a row of continuous fine catgut sutures. With fine catgut on a rounded needle (one without cutting-edges) unite the edges of the wound in the muscular wall of the bladder. If it can be accomplished without undue tension, bury the layer of muscle suture by a row of stitches inserted in the Lembert fashion and composed of fine silk or linen. It is very desirable to have an inverted wound with wide surface in apposition. Close the wound in the parietes after providing tubular or cigarette drainage for the prevesical space. If the bladder is completely closed as above, urine must be drawn off frequently by the catheter or permanent catheterization must be kept up. It is a very good and eminently safe precaution to provide perineal drainage before closing the vesical wound. This may be done as follows: Through the suprapubic opening pass a closed forceps through the internal meatus into the membranous urethra. Place the patient in the lithotomy position. With the forceps above mentioned make prominent the membranous urethra just behind the bulb. Cut down on the point of the forceps and with them seize and pull into the bladder the end of a soft-rubber catheter (No. 36 Fr. or larger). With a stitch fix the catheter to the perineal wound. Proceed with the closure of the suprapubic wound.

If it is desired to establish suprapubic drainage, partially close the wound, if it is too large, and introduce into the bladder a ¼-inch rubber tube or even two such tubes. The ends of the tubes should not impinge against the base of the bladder and they should be cut so as to be bevelled and be provided with lateral openings. In such cases it is wise to sew the bladder to the parietal fascia around the point of exit of the tubes. This is to prevent leakage of urine into the abdominal wound. When the vesical wound is not large and drainage is desired, one may proceed as follows: Dress a ¼-inch rubber drain by covering it with two or three layers of gauze; this in turn covered by rubber tissue (practically a cigarette drain with a tube through its centre). Introduce the end of the drain a very short distance into the bladder. With catgut suture the

edges of the bladder wound to the drain or its dressing. Push the tube a little further into the bladder; this inverts the edges of the bladder wound. In the Lembert fashion, with catgut, suture the surface of the bladder all around the wound to the tube. We thus have a double line of sutures (catgut) uniting the bladder to the tube and forming a water-tight joint. Fix the ends of the last row of sutures to the parietal fascia so as to keep the bladder in contact with the abdominal wall and close the wound in the latter. The water-tight joint around the tube is intended to keep urine and infection away from the prevesical fat and the abdominal wound until healing has progressed, to some extent, at least.

If from any cause it is deemed proper to leave the vesical wound entirely open, it is wise to attach its edges to the fascia abdominalis by a few points of suture, and to pack its cavity loosely with iodoform gauze.

It is easy to attach, with a glass joint, a long piece of tubing to the bladder drain and by siphonage conduct the urine to a suitable receptacle placed beneath the bed.

II. *Transverse Incision.*—Bardenheuer and many other surgeons prefer a transverse to a vertical incision, as more room is obtained. The disadvantage of this method is the liability to subsequent hernia. In cases of intravesical tumor the transverse incision is specially good. Place the patient in Trendelenburg's position. Make a slightly curved horizontal incision through the skin from the neighborhood of one external inguinal ring to the other, immediately above and parallel to the pubic bones. Divide the fascia covering the recti muscles. Separate the recti, pyramidales, and the linea alba from the bone. The retraction of the muscles gives a wide space for the subsequent work; if more space is required, separate the recti from each other vertically. The rest of the operation is the same as that already described.

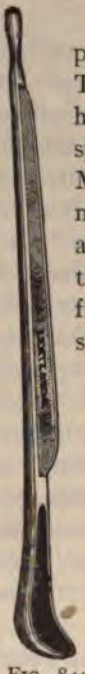


FIG. 842.—Lithotomy scoop.

FIG. 843.—Lithotomy forceps.

Suprapubic Lithotomy.—This operation is practically that of cystotomy plus the removal of the stone. If the calculus present is believed to be large, the transverse incision is the better, as it gives more room. It is bad practice to drag a stone out through too small an incision, as the resulting trauma is far more noxious than the making of a large opening by a sharp, purposeful cut. Calculi must be removed by appropriate forceps or scoop (Figs. 842 and 843).

In the absence of these special and very convenient instruments, common sense informs us that the same object may be attained, though less expeditiously, by the use of the fingers, ordinar y forceps, or a loop of wire. The suprapubic route insures a good surve y of the interior of the bladder, and hence prevents the not uncommon fault of overlooking a second or third stone. Remember that a second calculus may lie encysted in the pouch behind the prostate. When there is no great infection present, it is good practice to establish perineal drainage in the manner already described and close the suprapubic wound. If infection is considerable suprapubic drainage ought to be established, either alone or in combination with perineal. The after-treatment consists in keeping the bladder clean; the cystitis usually quickly subsides on removal of its cause.

Occasionally the stone may lie in a congenital or acquired diverticulum. If this is the case Fenwick advises fragmentation of the stone *in situ* by means of a chisel lightly struck by a mallet. In one case where the stone was unintentionally broken the author found great difficulty in removing the fragments. In another case where a stone, 3¾ x 1¼ x 1½ x 2¾ inches in diameter, lay in a diverticulum the mouth of which was only large enough to admit the forefinger, forcible dilatation of the opening permitted removal of the calculus, hemorrhage was trivial, and no evil seemed to result. (Excision of vesical diverticula, see page 712.)

Suprapubic Cystotomy for Benign Neoplasms.—Benign neoplasms are usually pedunculated; they may be single or multiple, sometimes being very numerous, filling up most of the space in the bladder. Most vesical papillomata bleed easily, and on account of this tendency it may be convenient to throw into the bladder, immediately before operation, a small quantity of a solution of adrenalin. The advantage gained by the use of adrenalin is that less bleeding occurs during the active operation, and hence the surgeon sees better what he is doing; whether hemorrhage is more or less liable to occur secondarily, *i.e.*, after the effects of the drug have worn off, is another matter, and not yet proved.

The bladder is opened preferably by the transverse incision, because of the free access obtained. When the tumor is pedunculated, seize its base in a curved clamp and cut away the free portion of the growth. Never drag upon the forceps so as forcibly to tear away the growth. Sometimes the tumor is so delicate that mere pressure with the forceps separates it from its base. When possible, excise with scissors the portion of the pedicle grasped by the forceps and close the wound in the mucous membrane with one or two points of catgut suture. The finger of an assistant pushing up the bladder from the rectum may aid greatly in this work when the site of the trouble is on the posterior bladder-wall. If the tumor is sessile or has a broad base, cut it away with scissors, as close to the bladder-wall as possible, and cauterize the stump with the thermo-cautery. Some surgeons operate on tumors and various bladder-lesions through a kind of coffer-dam, so as to avoid urine and blood from other parts obscuring the field of operation. The model on which all such coffer-dams are made is the old Ferguson's tubular vaginal speculum, passed through the abdominal wound and enclosing in its distal opening the area to be attacked. The coffer-dam undoubtedly is a great aid in operating, but it has the serious disadvantage of

requiring, for many purposes, the use of special scissors and forceps to permit of work being done through its narrow lumen. After the removal of tumors drainage is essential, and the use of various antiseptic and more especially astringent douches is advantageous. Repeated operations may be necessary before all the neoplasms are removed. If hemorrhage is alarming, the bleeding areas may be packed with iodoform gauze.

Nitze and Sonnenburg write as follows ("Handbuch der practischen Chir.," iii, 838): "Passing one or two fingers gently into the bladder, one informs himself as to the nature of the tumor and the manner of its origin on the bladder-wall. If, as is very common, the tumor is a large, solid villous growth with a pedicle, or if a pedicle can be formed by cautious pulling on the tumor, catch it gently but firmly between the fore- and middle fingers and pull it upwards from the mucous membrane for such a distance that a curved forceps or clamp can be applied to the pedicle between the fingers and the mucosa. By careful, but strong traction on the locked forceps, endeavor to bring the base of the tumor up to the level of the external wound. It is astonishing how far up continued traction can bring the mucous membrane of the base of the bladder without injury to the patient. If the tumor is large, it often prevents ocular inspection of the mucosa around its base and the necessary recognition of the ureteral openings. Under these circumstances one tears away the villous masses from their pedicle; no hemorrhage results because the forceps are *in situ* compressing the pedicle. The whole field of operation being exposed to view, pass two silver wires through the portion of bladder-wall that is pulled up by the forceps, at a considerable distance from the pedicle, and then with the knife or cautery (knife-blade) excise the pedicle, and with it some of the surrounding mucosa. Injury to the ureters can usually be avoided during the extirpation of benign neoplasms even if the latter are situated at their orifices, but their injury generally does no harm; even complete excision of the ureteral orifices is well borne. After extirpation of the base of the tumor the silver wires already in place prevent retraction of the field of operation and thus hemorrhage can be more readily attended to, and sutures introduced, after which the silver wires are removed."

Malignant neoplasms cannot be efficiently treated in the above fashion. All nibbling, hesitating methods are worse than useless, merely stimulating to increased rapidity of growth. The principles of operation are identical with those for operation on carcinoma located elsewhere, viz., wide and complete removal, partial or total cystectomy.

The most serious form of non-malignant ulcer of the bladder is the tuberculous, and this will be taken as the type in discussing the operative treatment of ulcer. As in other locations, so also in the bladder rest is a *sine qua non* of treatment. Drainage through the suprapubic, the perineal, or through both routes is the best means of obtaining the necessary rest, and in cases of simple ulceration may be essentially all the treatment required. When the ulceration is tuberculous, further operative treatment is necessary. Open and explore the bladder. A cold electric lamp introduced through the wound is a great aid, as also is light from a head-mirror or lamp. If the ulcer is solitary, limited in extent, and situated on the anterior part of the bladder from

which the peritoneum can be stripped, it is wise to excise the affected portion of vesical wall and close the wound completely after providing perineal drainage. If the ulcer is situated at the base of the bladder—and this is commonly the case—cauterize it with the thermocautery or with pure formalin and rub iodoform into it. The subsequent local treatment must consist of drainage and lavage with suitable antiseptic lotions. General treatment is of the utmost importance—good food, fresh air, tonics, and some form of guaiacol are our main reliances.

The natural resisting power of the bladder against tuberculosis is well illustrated in cases of tuberculous nephritis and ureteritis in which secondary lesions appear in the bladder around the ureteral orifices. After nephrectomy and ureterectomy the vesical lesions often disappear spontaneously. This fact encourages us in the treatment of vesical tuberculosis.

Suprapubic Prostatectomy and Prostatotomy.—Open the bladder and explore so as to recognize the variety of prostatic enlargement present and the presence or absence of vesical calculi. If the latter are present, remove them.

I. *Enlarged Pedunculated Middle Lobe.*—This lobe may be the sole obstacle to urination, forming a valve which occludes the vesical meatus.

Method A: Cut through the pedicle with scissors and remove the lobe. Hemorrhage is easily controlled by temporary pressure with pads wrung out of hot water.

Method B: Incise or tear through the mucosa covering the lobe and shell it out with the finger. This method is available whether the hypertrophied lobe is pedunculated or not.

Never omit to examine the prostatic urethra, lest the lateral lobes impinge upon it and require removal.

II. *Enlarged Lateral Lobes with or without Enlargement of the Middle Lobe.*—Introduce a gum-elastic catheter into the bladder through the urethra, to act as a guide to the position of the prostatic urethra. Make an incision through the mucous membrane over the most prominent part of the swelling. With the finger, aided if necessary by closed blunt-pointed scissors, peel the mucosa from the surface of the prostate. Insinuate the finger through the mucosal wound, between the prostate and the urethra, and separate these structures. In the same way separate the outer surface of the prostate from its surroundings, the finger passing between the true and false prostatic capsules. The fingers of an assistant should be passed through the anus to elevate and steady the prostate. Working as above, the prostate may be removed in one piece or in two or more sections. Freyer is often successful in leaving the prostatic urethra intact, though when it is injured no harm seems to result. Moynihan removes the prostatic urethra with the gland. It is claimed that when the two lateral lobes are removed separately the ejaculatory ducts are not destroyed. The author for a number of years has omitted the use of any catheter or sound as a guide. He introduces his finger through the suprapubic wound into the internal or vesical meatus, with his finger nail penetrates the mucosa and shells out the enlarged lobes. In this procedure he has the support of L. L. McArthur ("Surg., Gyn., Obst.," Ap. 10, p. 412). Hemorrhage is easily controlled by temporary pressure with pads wrung out of hot water. Freyer introduces

a large drain into the bladder through the abdominal wound and sutures the vesical wound around it. Through the tube irrigation with hot water may be practised and any blood-clots removed. The drain is kept in position for about one week, when it is removed and the wound permitted to close. Fuller, after completing the enucleation of the prostate, establishes perineal drainage and closes the suprapubic wound. In cases in which there is much infection it is probably best to maintain both perineal and suprapubic drainage for a few days. Prostatectomy via the perineal route will be described on another page.

W. E. Lower (Annals Surg., Feb., 1914) strongly recommends Crile's anociassociation in prostatectomy as it eliminates shock. He operates as follows:

One hour before operation give a hypodermic injection of morphine and scopolamine.

Immediately before the operation irrigate the bladder and inject 60 to 90 c.c. of a 5 per cent. solution of alapin through a catheter which is then clamped and left *in situ*.

Administer nitrous oxide and oxygen.

Perform suprapubic cystotomy after infiltrating the skin and all the tissue planes as well as the bladder-wall with a ¼ per cent. solution of novocaine.

Gently retract the wound in the bladder with four suitable retractors and inject the prostatic capsule with the novocaine solution.

Enucleate the prostate. N. B.: The catheter is still *in situ*.

Push the vesical mucosa which covered the prostate down into the cavity left by the enucleation, so that the vesical mucosa meets the urethral mucosa. Keep the mucosa in position by narrow strips of gauze packed over it and around the point of the catheter. The ends of the gauze come out through the vesical wound.

Paul M. Pilcher (Surg., Gyn. and Obst., Feb., 1917) emphasizes the importance of renal decompression before removing the prostate. The Pilcher operation is done in two stages.

Stage 1.—*Suprapubic Cystotomy.*—Under local anesthesia open the bladder as near its fundus as possible after brushing the peritoneal fold upwards. Introduce a Pezzer catheter through the wound and make a water tight closure of the vesical wound round the catheter by means of a purse string suture of catgut. Close the abdominal wound by deep and superficial sutures. The result ought to be primary union, no leak, and effective sealing of the peri- and prevesical spaces. When the urinary output has regulated itself as regards quantity and quality proceed to Stage 2, usually in from one to two weeks.

Stage 2. *Step* 1.—Administer a general anesthetic. If less than two weeks have elapsed since the primary operation it is easy to enlarge the drainage opening with the finger. If cicatrization is more complete enlarge the opening by a short (1 inch) *transverse* incision on each side of the drainage track. These incisions as a rule, only penetrate to the recti-muscles.

Step 2.—Introduce the finger and enucleate the prostate in the usual manner.

Step 3.—Pass a metal catheter *per urethram* into the bladder. Place the open end of the urethral tube of Pilcher's bag hemostat (Fig. 844) over the end

of the catheter and fix it by a stitch passing through the eye of the catheter. Withdraw the silver catheter and thus pull the rubber tube through the urethra and the bag hemostat into the neck of the bladder. Distend the bag with air. Bring the inflating tube out through the suprapubic opening. This procedure controls hemorrhage and secures drainage through the urethra.

Pass a rubber tube about 1 inch in diameter through the suprapubic wound, to project into the bladder for about ½ inch. Fix this tube to the skin by sutures. Connect the drain by tubing to an appropriate bottle to collect the secretions.

FIG. 844.—Pilcher's bag hemostat. (*Surg., Gyn. and Obst.*)

FIG. 845.—Pilcher's modified Pezzer catheter. (*Surg., Gyn. and Obst.*)

After from 24 to 48 hours remove the bag hemostat and drainage tube. Replace them by Pilcher's modification of Pezzer's catheter (Fig. 845), which after a few hours should drain off all the urine without leakage. After about one week the drain may be temporarily closed and urine may be passed *per urethram*. Generally the drain may be removed on the eleventh day.

Cystectomy.—Cystectomy may be partial or complete.

Partial Cystectomy.—This operation is mostly commonly indicated in cases of circumscribed malignant neoplasm, and whenever feasible should be carried out extraperitoneally. The anterior wall, most of the fundus, and sometimes even part of the posterior wall of the bladder may be exposed without opening the peritoneal cavity. Expose the bladder as in suprapubic cystotomy. Carefully pull the prevesical fold of peritoneum upwards, and by blunt dissection separate its vesical layer from the bladder to the desired extent. If the peritoneum is accidentally torn, the tear must be at once closed with sutures. Having exposed the bladder at the site of the tumor (anterior wall or fundus), open it and remove the whole thickness of the diseased portion, making the necessary cuts in healthy tissue. Remove too much rather than too little tissue along with the neoplasm. Close the wound by sutures exactly as in suprapubic cystotomy, after providing for drainage—preferably through the perineum.

If the neoplasm has infiltrated the bladder-wall so as to attack the peritoneal covering and its location is favorable, the operation may still be accomplished practically extraperitoneally. Expose the bladder and reflect the peritoneum from it except where it is adherent over the site of the neoplasm; with scissors cut around the site of adhesions; with sutures close the gap in the peritoneum and remove the diseased cystic wall as already described.

When the disease affects the posterior bladder-wall, but does not infiltrate the peritoneal covering, it may be removed as follows: Apply a solution of adrenalin to the bladder so as to control hemorrhage, not from any fear of loss of blood, but to keep blood from obstructing the view. Incise the bladder-wall all around the neoplasm, cutting in healthy tissue. Cut down to but not through the peritoneal coat. Remove the disease, along with the whole thickness of the wall, minus the peritoneal covering. Close the wound by a layer of sutures (catgut) involving the muscular coats alone, and one involving the mucosa alone. Should the peritoneum be accidentally opened, close it at once by a few catgut or fine silk sutures. The operation as above described involves more precise suturing than most surgeons are capable of doing. It must require marvelous skill to suture *with precision* the various vesical coats when the work has to be done at the bottom of a deep cavity. If the peritoneal covering is uninjured, probably the best method to pursue is to make the stitches involve the muscular and mucous coats. These stitches will probably not secure complete union; there will be separation of the edges in time, but they will lessen the size of the defect and so hasten recovery. If it is possible to pull the wound up towards the surface of the body, then of course its closure is easy.

When the tumor is situated at the trigone, the operation is very much as above described. One cuts through the bladder-wall layer by layer until the perivesical fat is reached, and then removes the disease. If the ureter is involved in the disease, pass a catheter into it and dissect it free from its surroundings for about two inches; remove such part of it as may be diseased; secure its ends temporarily by a thread. After the resection of the bladder-wall is completed unite the ureter once more to the bladder. Occasionally it has been necessary to anastomose the ureter to the rectum or skin; this is very undesirable.

Transperitoneal Partial Cystectomy.—Francis Harrington ("Annals Surg.," 1893), struck by the safety with which wounds of the bladder, accidentally inflicted during laparotomy, may be sutured, boldly opened the bladder through the peritoneal route. C. H. Mayo followed Harrington with a number of successful operations for vesical neoplasms.

The Operation.—Wash out and empty the bladder completely. Put the patient in Trendelenburg's position.

1. Make a median incision between the pubis and umbilicus about 6 inches long. Open the peritoneum. Thoroughly pack with gauze to keep the intestines away and to protect the belly cavity.

2. Pick up the bladder with two volsellæ and incise it between them. The incision is median and about 2 inches in length. With gauze mop out any [illegible] in the bladder. Enlarge the incision in the bladder upwards and [illegible]

ds until the cut equals one-third or more of the vertical circumference of viscus.

3. If the tumors are pedunculated and benign, cut through them flush with vesical mucosa and burn the wound with a cautery (Fig. 846).

If the tumors are sessile and benign, remove them and burn their site.

FIG. 846.—Partial cystectomy. (*Mayo.*)

If the tumors are malignant, excise them with the mucosa by means of cautery knife. Do not try to destroy the growth with the cautery, but t up with forceps and dissect it away, using the cautery as a knife.

. Close the wound in the bladder by through-and-through catgut stitches oduced in the Connel fashion (Fig. 847). Put in a second layer of stitches ap) in the continuous Lembert or Cushing fashion. At the lower end of cut, where the bladder is not covered with peritoneum, it is easy to so loosen parietal peritoneum continuous with the vesical peritoneum that it can be e to lie on the bladder and permit the continuation of the Lembert suture

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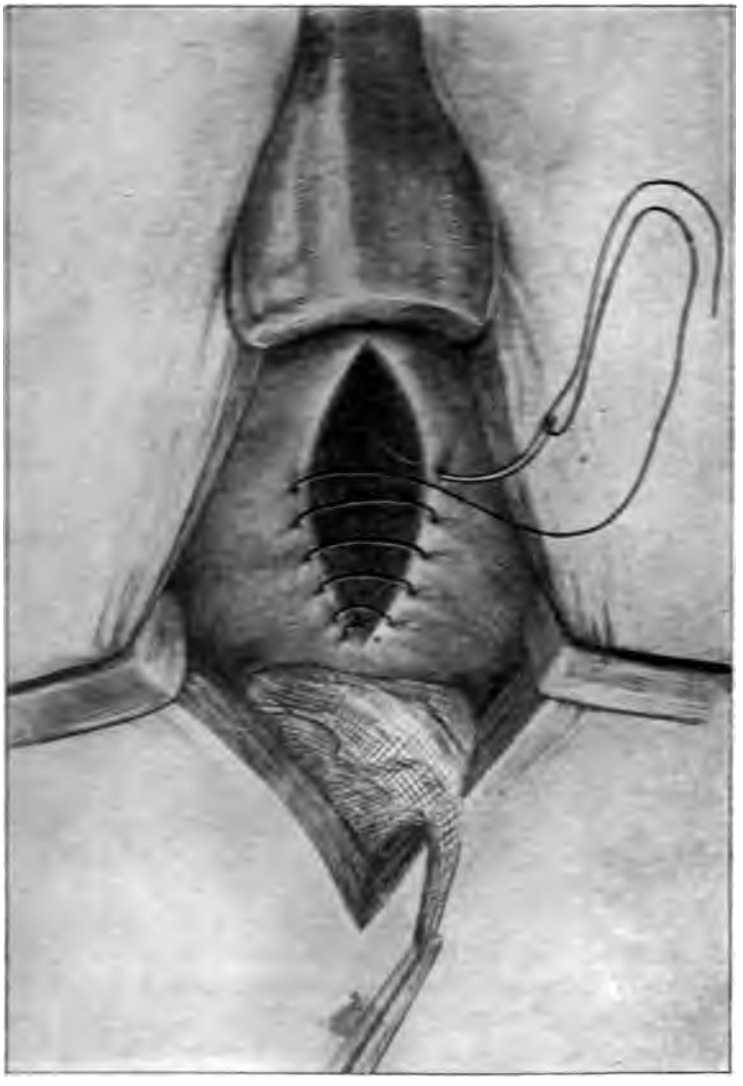

FIG. 417.—Partial cystectomy. Suture of bladder. *Mayo.*

(b) Make a stab wound in the bladder about $\frac{3}{4}$ inch to the right of the lower end of the vesical wound. Introduce a split rubber tube containing a strand of gauze into the bladder and bring it out through the lower end of the abdominal wound. With fine catgut, suture the parietal to the vesical peritoneum just external to the stab wound in the bladder and continue this

stitching so as to unite the parietal to the vesical peritoneum just above the line of the drainage tube.

The object of this elaborate method of drainage is to avoid (*a*) contamination of the belly cavity with urine escaping along the drain; (*b*) contamination of the line of Lembert sutures.

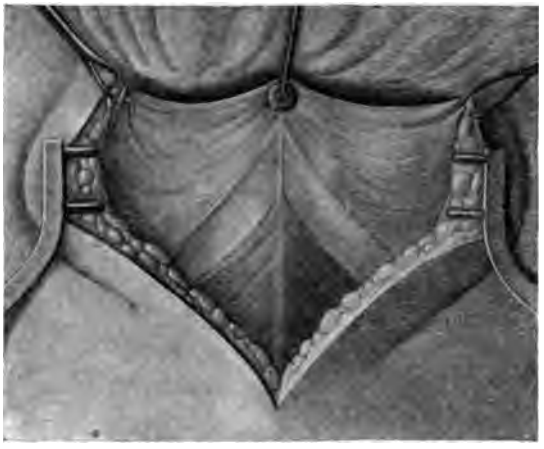

FIG. 848.—(*Squier and Heyd, Surg., Gyn. and Obst.*)
Exposure of prevesicle space. Urachus and divergent obliterated hypogastric arteries held taut by intestinal forceps.

5. Close the abdominal wound. If drainage is not used, draw off the urine with a catheter as may be necessary; commonly the urine is voided voluntarily. If drainage is used, the dressings must be removed frequently.

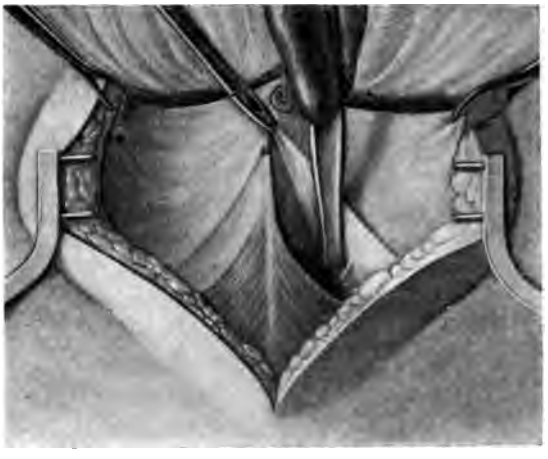

FIG. 849.—(*Squier and Heyd, Surg., Gyn. and Obst.*)
Exposure of left ureter by blunt dissection along the course of left obliterated hypogastric artery

An account of Young's method of partial cystectomy is given in the section on Excision of the Seminal Vesicles.

Squier-Heyd Operation (Surg., Gyn. and Obst., July, 1914).—*Step* 1.—From a point one inch above and to the left of the umbilicus make an incision down-

wards to a point two inches above the pubis in the middle line. Open the pe toneum. Place the patient in the extreme Trendelenburg position. Push t intestines towards the diaphragm. Thoroughly isolate the field of operati with gauze pads.

FIG. 850.—(*Squier and Heyd, Surg., Gyn and Obst.*)
Exposure of left ureter by blunt dissection along the course of the left vas deferens.

Step 2.—Continue the incision downwards through the skin and fascia. Divide the pyramidales transversely at the pubis. Expose the prevesical space but do *not* interfere with the pubo-vesical attachment at any stage in the operation.

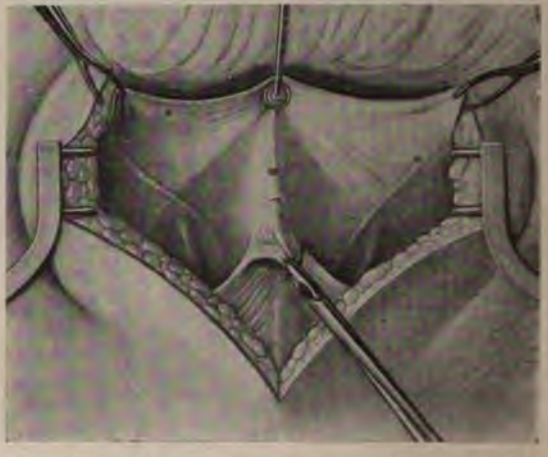

FIG. 851.—(*Squier and Heyd, Surg., Gyn. and Obst.*)
Final separation peritoneum from bladder, exposing both ureters, vasa deferentia and upper pole of trigone.

Step 3.—At the lower angle of the peritoneal incision catch the urachus and peritoneum with a forceps protected by rubber tubing (Fig. 848). Pull on the forceps upwards and make prominent the obliterated hypogastric vessels hypogastric cords).

Step 4.—Pull the left hypogastric cord upwards and to the right. By blunt dissection between the cord and the lateral wall of the pelvis, expose the left vas deferens as it runs along the pelvic wall to the inner side of the hypogastric cord (Fig. 849).

FIG. 852.—(*Squier and Heyd, Surg., Gyn. and Obst.*)
Bladder pulled down towards symphysis. Primary incision in bladder.

Step 5.—Exert gentle traction on the exposed vas, and dissect bluntly downwards along it until the pelvic ureter is exposed as it bends inwards above the fascia of the pelvic floor to enter the bladder. At this point the ureter is crossed on its inner side by the vas (Fig. 850).

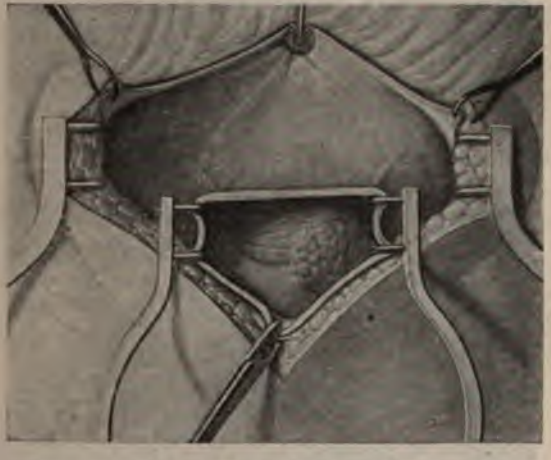

FIG. 853.—(*Squier and Heyd, Surg., Gyn. and Obst.*)
Bladder wound enlarged downwards.

Repeat Step 4 and 5 on the right side.

Step 6.—Divide the urachus close to the bladder (Fig. 851). Strip the peritoneum from the bladder until the recto-vesical space is reached. Push Douglas' cul-de-sac upwards and backwards. Pull the bladder downwards

FIG. 854.—(*Squier and Heyd, Surg., Gyn. and Obst.*)
Bisection posterior wall bladder.

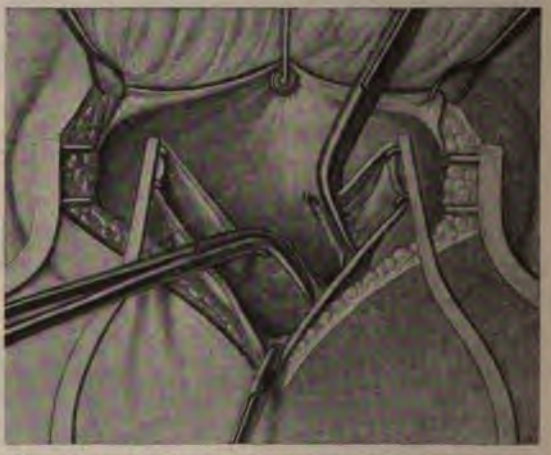

FIG. 855.—(*Squier and Heyd, Surg., Gyn. and Obst.*)
Neoplasm and affected ureter excised, *en masse* with much healthy tissue. Hemostasis with angled forceps. Temporary ligature around proximal ureter.

FIG. 856.—(*Squier and Heyd, Surg., Gyn. and Obst.*)
Partial closure of bladder wound. Stab wound for implantation of ureter. Porceps grasping ureter.

the symphysis until the upper poles of the seminal vesicles are exposed.
ole fundus of the bladder and the upper portion of the trigone are fully
. The ureters are constantly in sight. There is little bleeding.
7.—Carefully unite the denuded lamella of the peritoneum to the upper
he abdominal incision so that all the subsequent procedures are extra-
eal.

FIG. 857.—(*Squier and Heyd, Surg., Gyn. and Obst.*)
Implantation of divided ureter after partial closure of the bladder.

rest of the operation is sufficiently described by Figs. 852–859 with
nds under them.
er and Heyd note that fifteen patients were operated on by their method
ears with no operative mortality.
the last three the technique was carried out without entering the
eal cavity, thereby making the operation entirely extra-peritoneal.
tion, approximately the same technique has been utilized for removing
at the lower end of the ureter and for an extensive resection for diver-
of the bladder."

FIG. 858.—(*Squier and Heyd, Surg., Gyn. and Obst.*)
Counter-opening for drainage of bladder.

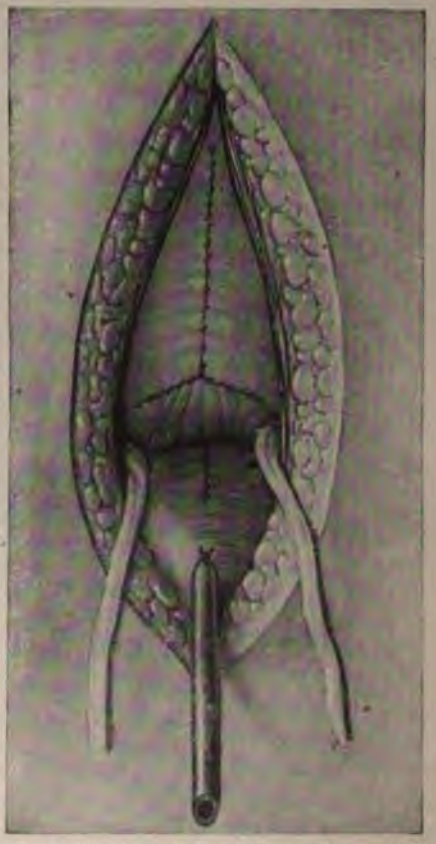

FIG. 859.—(*Squier and Heyd, Surg., Gyn. and Obst.*)
Accurate closure of the peritoneal cavity showing the two cigarette drains and separate stab-wound drainage of bladder.

Rutkowski's Operation for the Repair of Defects in the Bladder-wall.—Scope of operation: Rutkowski's operation may be used to close the bladder in cases of ectopia. It also promises to be useful in repairing the bladder after the removal of tumors. In describing the operation it will be assumed that the case is one of tumor.

The Operation.—1. Open the belly by a 4-inch incision in the middle line near the pubis. Expose the bladder.

2. Excise the tumor and as much of the vesical wall as may be necessary.

3. Pull a loop of ileum down towards the bladder and divide it at two places (x–x, Fig. 860). The distance between the two lines of section (x–x) depends on the size of the defect in the bladder which it is desired to close.

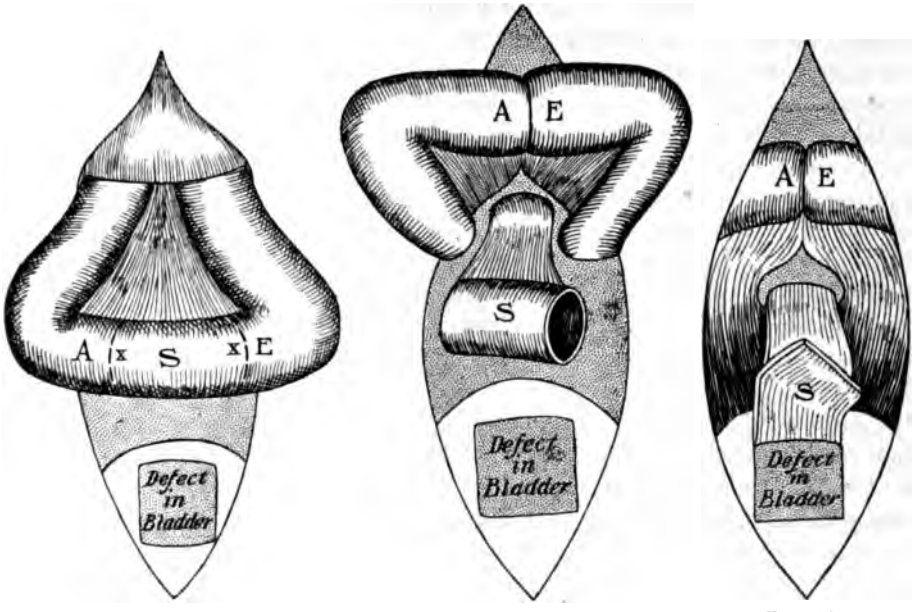

FIG. 860. FIG. 861. FIG. 862.

FIGS. 860, 861 AND 862.—Rutkowski's operation.

4. The afferent and efferent loops of ileum (A and E, Figs. 860 and 861) are united by end-to-end anastomosis and at once returned to the abdominal cavity.

5. The isolated segment of ileum (S, Figs. 860 and 861) is split along its free border (*i.e.*, along the side opposite to the mesenteric attachment). A flap of tissue is thus obtained (S, Fig. 862) which is rectangular in shape, covered on one side by mucous membrane, on the other by peritoneum, and contains non-striated muscular fibres. To the middle of its serous surface is attached the mesentery through which it is nourished.

6. The edges of the flap are attached to the edges of the defect in the bladder by a double layer of sutures. The mucous surface of the flap faces the interior of the bladder. The deep layer of sutures (catgut) includes the whole [redacted] of the bladder and of the gut walls except the surface of the mucous

membrane. The superficial layer (silk) is applied after the Lembert method. Continuous sutures are used.

7. A catheter is passed into the bladder *per urethram* and is kept there.

8. The abdominal wound is closed.

Mikulicz has modified the above operation. After isolating a segment of ileum and uniting the afferent and efferent loops (Step 4), he closes, by suture, one end of the isolated segment and sutures the other, or open end, to the abdominal wound near the bladder. The abdominal wound is closed. After a sufficient period of time has elapsed to demonstrate that the segment of ileum is sufficiently nourished, he proceeds to remove the vesical tumor and repair the bladder with the segment of ileum obtained at the first operation.

Complete Cystectomy.—Tuffier ("Revue de Chir.," April, 1898) reports a successful case of complete cystectomy in a man suffering from extensive epithelioma confined to the bladder. In his case the operation was complicated by a previous suprapubic cystotomy having been practised. The complication was overcome by packing the bladder with gauze and by dissecting the fistulous tract free from the parietes. Ample room for work was obtained by a combination of the transverse and vertical incisions recommended in cystotomy. The steps of the operation were, briefly, as follows: Exposure of the anterior surface of the bladder. Separation of the anterior and lateral surfaces from the peritoneum and adjacent structures. It is thus easy to isolate the neck of the bladder and the pedicles containing the inferior vesical vessels and the ureters. Clamp the vessels and ureters together and cut between the clamps and the bladder. Divide the neck of the bladder between clamps and cauterize the opened urethra. It may be well to make the division of the vesical neck with the cautery. With forceps or clamps pull the bladder into the abdominal wound and decorticate, *i.e.*, separate it from its peritoneal covering under traction. Tuffier succeeded in doing this without opening the peritoneal cavity. If the peritoneum is torn, the opening must be closed at once with sutures. Having removed the bladder, turn to the pedicles containing the vesical vessels and ureters. Isolate the ureters and tie the vessels. Pass a catheter into each ureter and fix it to the ureter with a stitch. Ligate the vessels in the urethral stump.

In Tuffier's case he at once anastomosed the ureters to the rectum, but the union evidently gave way, as the patient developed a suprapubic fistula. If the patient is in poor condition, it is wise to bring the ureteral catheters out through the suprapubic wound and leave any attempts at anastomosis until later. After attending to hemostasis, pack the cavity with gauze and partially close the wound with sutures. Tuffier's classical case lived in comfort for seven months. In the female, Pawlik operated in two stages with an interval of about three weeks. His operation may be performed as follows:

First Stage.—Uretero-vaginal anastomosis. Catheterize the ureters. Incise the vagina over each ureter. Divide and bring the end of each ureter into the vagina. Split the lower end of each ureter for about ½ inch and suture the edges of the split to the vaginal wound. Fix with stitches a catheter in each ureter.

Instead of practising any method of ureteral implantation, Frank Watson advises permanent nephrostomy.

Second Stage.—Excision of the bladder. Fill the bladder with an emulsion of iodoform. Through a suprapubic incision separate the bladder from its surroundings down to the urethra. Empty the bladder. Pack the suprapubic wound with gauze. Make an incision through the anterior wall of the vagina at a point opposite the internal urinary meatus, pull the isolated bladder through this incision, and divide it where it joins the urethra. Remove the bladder. Pass ureteral catheters through the urethra into the ureters. Denude and close by sutures the vaginal outlet, thus forming a urinary reservoir drained by the urethra.

F. S. Watson recommends nephrostomy as a preliminary to complete cystectomy.

Rovsing (German Surg. Assoc., 1907) advises the removal of the bladder as if it was a cystic tumor without opening it.

Step 1.—Fill the bladder with a mild antiseptic solution. Put the patient in Trendelenburg's posture. Expose the distended bladder through a curved transverse incision (convexity downwards), near the pubis.

Step 2.—Separate the vertex and sides of the bladder from their connections. While doing this doubly ligate and divide all strong bands of tissue containing vessels. If possible separate the posterior wall from its peritoneal covering. If the infiltrated bladder wall is firmly adherent to the peritoneum, open the belly cavity and remove the bladder with its peritoneal covering.

Step 3.—Expose, doubly ligate, and divide the ureters about ½ to ¾ inch from the bladder.

Step 4.—(*a*) In the female it is easy to free by blunt dissection the neck of the bladder and about ¾ inch of the urethra. Clamp and divide the urethra.

(*b*) In the male separate the base of the bladder and the prostate from the rectum. This leaves the bladder attached to the body by the membranous urethra alone. Doubly clamp and divide the urethra. Leave the distal clamp *in situ* for 24 hours to prevent bleeding from the cavernous tissue.

Step 5.—If the peritoneum has been opened, close it with sutures. Pack the cavity with gauze which is brought out through the middle of the wound. Unite the wounded recti muscles. Close the excess of wound. Apply dressings.

Step 6.—Expose both ureters through a 3- to 4-inch incision on each side running obliquely outwards and downwards from the edge of the erector spinæ muscles. The ureters can be palpated close to the pelvis of the kidney. Fix the ureters with a finger, and with another finger bluntly dissect them loose throughout their whole length and pull them out of the lumbar wounds. Close the lumbar wounds with sutures, leaving the ureters hanging loosely out of them. Pass a No. 12 catheter into each ureter to prevent its compression by the wound. Pull the exposed part of each ureter through the perforated finger of a rubber glove to protect the wound. Apply dressings. By the time the lumbar wounds have healed the excess of ureter has become shrunken and

necrosed, and may be removed. Rovsing has performed the above operation three times, twice successfully.

J. Verhoogen ("Journ. de Chir.," March, 1907; ref. "Zent. für Chir.," 1907, No. 32) recommends the following operation:

(1) Open the abdomen. Explore as to extent of disease, adhesions, etc.

(2) Expose the ureters where they cross the vessels at the pelvic brim.

(3) Anastomose the right ureter to the cæcum, the left to the sigmoid. Make the anastomoses valvular, like Witzel's gastrostomy.

(4) Excise the bladder, forming an anterior and posterior peritoneal flap.

(5) Drain through the vagina, or, in the male, through the perineum after removing the prostate.

(6) Close the abdominal wound entirely.

Operative removal of benign neoplasms gives good results; the extirpation of malignant growths occasionally does so.

Prostatotomy.—The principle at the base of all operations for the relief of the troubles arising from enlarged prostate is the provision of drainage for the most dependent portion of the bladder. Such drainage may be secured by suprapubic prostatotomy.

Expose and open the bladder by the vertical incision. Explore the bladder and recognize the nature of the prostatic obstruction. Introduce a tubular speculum (caisson or coffer-dam) and engage the prostate in its open end. The use of this is not essential. With gauze dry the surface of the tissues enclosed in the end of the speculum. Pass a thermocautery, heated to a red heat, through the speculum and burn a groove or gutter from the prostatic urethra to the vesical pouch behind the prostate. This provides drainage of the most dependent portion of the bladder. If the lateral lobes of the prostate obstruct the urethra, it is well to burn deep grooves or gutters in them also. Provide suprapubic drainage and partially close the wound. This operation is very similar in principle to the Bottini operation, but it is done under guidance of the eye.

Galvano-caustic Prostatotomy (Bottini's Operation).—The object of the Bottini operation is to make one or more furrows through the obstructing prostate, thus lowering the vesical orifice of the urethra and permitting efficient drainage of the bladder.

The favorite instrument for division of the prostate is Freudenberg's modification of Bottini's galvanocautery (Fig. 863). H. Young has devised an instrument in which various sized blades can be used ("Jour. Am. Med. Assoc.," Jan. 11, 1902).

Da Costa thus describes the operation: "The bladder should be emptied, irrigated, and distended with air, and the posterior urethra must be anesthetized by instillation of cocain or eucain. The current is tried to see how many seconds it requires to heat the blade sufficiently. The current is broken, the instrument is introduced, the cooling current is set in motion, and one assistant watches this and nothing else. Turn on the current. Wait the required number of seconds for the blade to become red hot (twelve to fifteen seconds), turn the screw at the handle, and burn a groove in the prostate. A

groove should be burned towards the rectum, one to the side, and, if it is thought desirable, one to the opposite side. No groove should be burned towards the pubes. When a groove has been burned, return the blade into its sheath, increasing the current while doing so in order to keep the blade from adhering to the tissue, and then shut off the current. After withdrawing the instrument it is not necessary to introduce and retain a catheter. The patient is confined to bed only twenty-four hours, there is rarely bleeding or fever, and the results are good. The scars contract and the gland atrophies. During the period of healing a steel sound should be passed from time to time (Bangs)."

Chetwood has devised a short cautery which he introduces through a perineal opening and so escapes the grave danger of urethral injury mentioned on page 704.

For the indirect treatment of prostatic hypertrophy J. W. White has strongly recommended castration, and R. Harrison and Mears vasectomy (division or resection of the vasa deferentia). These operations are too simple to require description.

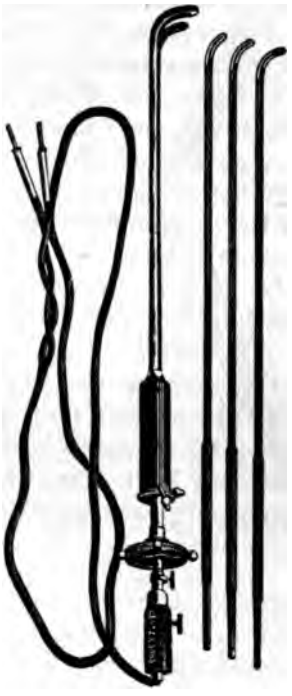

FIG. 863.—Cautery. (*De Costa.*)

Remarks on the Treatment of Prostatic Hypertrophy.—The patients are almost always aged in years, and still more aged in physical condition. Unfortunately, until recently, operation has been considered the last resort, hence the patients have been permitted to get into a very dreadful condition. The operation required for cure is always one of severity, hence if the patient can be kept in a fair state of comfort and health by palliative treatment, such treatment is the best. Whenever hygienic measures and the proper use of the catheter fail to give relief, it is wrong to waste time; the patient must be given the option of radical treatment.

Castration or orchidectomy is the least efficacious method of treatment, and having a high rate of mortality and of induced insanity, it has been practically discarded. Vasectomy possesses any advantages which may pertain to castration and is much less dangerous. It has no effect on fibrous and adenomatous enlargement, but favorably influences congestive conditions. It seems to be of use in cases of "prostatismus" where the symptoms of prostatic hypertrophy are present, but there is no residual urine. Wassiljew ("Centralblatt f. Chir.," 1903, No. 26) thinks the benefits derived are due to the resulting lowering of the tone of the vesical sphincter.

The main objects aimed at by operations on the prostate are (1) removal of the cause of the obstruction, (2) lowering of the vesical mouth of the urethra so that the bladder may empty itself.

The most surgical means of attaining the above objects is by prostatectomy, either suprapubic or perineal. Both of these methods are good in suitable

cases. Where the perineum is deep, or where the hypertrophy is mainly intravesical, the suprapubic route is the better. Most forms of hypertrophy can be removed by the perineal route, and this route gives the better drainage. Suprapubic prostatectomy, is the favorite with most surgeons. Whichever method is chosen, the operation is one of severity and ought not to be undertaken when renal disease is present. Prostatotomy, whether accomplished via the suprapubic route by means of a thermocautery or through the urethra, as in the Bottini operation, attains one of the objects of radical operation in that it lowers the vesical orifice of the urethra. The suprapubic method has the advantage of being done under the guidance of the eye, with inexpensive instruments, and of requiring no special manual training. The disadvantages are the necessary suprapubic cystotomy, and the fact that the resulting scar in the prostate is thicker and clumsier than that left by the galvanocautery. The Bottini operation has been thoroughly tested by many surgeons, notably by Horwitz and Willy Meyer, the latter having operated 71 times on 59 patients without any reference to the character of the lesion or the presence of renal or other disease. Out of the 59 cases 7 died, but the death was the direct consequence of the operation in but 3.

The author has seen one case in which, owing to some unsuspected flaw in the instrument used, the urethra was severely burned, and in part obliterated, while the prostate itself had escaped without being cauterized. The condition of the prostate was demonstrated during a subsequent suprapubic operation done by J. Block to establish drainage. The original operator was a surgeon of great experience in this class of work.

CHAPTER L

PERINEAL SECTION

PERINEAL CYSTOTOMY

Perineal cystotomy, or the boutonnière operation, is perhaps the simplest and safest method of opening and exploring the bladder. As a method of exploration it is defective in that it is difficult to reach all parts of the bladder with the finger, especially when the perineum is deep. Ocular inspection is also impossible. As a therapeutic agent it is of great value in providing drainage and giving rest, not merely to the bladder, but to the urethra; it also permits the removal of small calculi and neoplasms from the bladder. Perineal cystotomy is one of the steps in certain methods of perineal prostatectomy.

Preparation of the Patient.—Thoroughly evacuate the large intestine by means of irrigation. Irrigate the bladder and partially fill it with warm water or boracic acid solution. Shave the perineum. Cleanse the perineum, scrotum, penis, and hypogastric region. Place the patient in the lithotomy position with the buttocks elevated and well over the edge of the table.

The Operation.—*Step* 1.—Pass a staff, provided with a median groove on its convex side, into the bladder. By holding the handle of the staff close to the hypogastrium force its curve against the perineum, which is thus

made prominent. Intrust the staff to an assistant, who holds it steadily and accurately in place. The surgeon now sits down, facing the field of operation.

Step 2.—Protect the hand with a rubber glove and, *per rectum*, palpate the prostate, etc. Having done this, remove the glove. With the fingers of the left hand steady the skin of the perineum and make a median incision from a point posterior to the scroto-perineal junction to within one inch of the anus. Keeping strictly in the middle line, deepen the incision until the urethral bulb is exposed. Do not injure this structure. Pull the bulb forwards in the middle line and continue the dissection behind it until the staff can be felt in the membranous urethra. Open the urethra on the staff, and freely incise it from the bulb to the apex of the prostate.

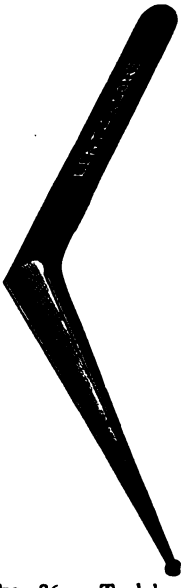

FIG. 864.—Teale's gorget.

Step 3.—Guided by the groove in the staff pass a curved grooved director or a Teale's gorget (Fig. 864) into the bladder. Remove the staff. Along the director or gorget push the finger into the bladder with a boring motion. This forcibly dilates the prostatic urethra. With the finger explore for calculi, neoplasm, enlarged prostate, etc. If a small calculus is present, remove it with a lithotomy forceps or scoop. If a small, benign, pedunculated neoplasm presents, remove it with the finger or by crushing its pedicle with forceps. Be careful not to drag forcibly on the tumor. Sessile or large tumors are better attacked through a suprapubic incision.

Step 4.—Having finished the exploration or the active operation, introduce a drainage-tube approximately equal in size to the exploring finger. Watson's drainage-tube is excellent (Fig. 865). R. Harrison uses a large rubber catheter with a terminal as well as lateral eye. With one or two points of suture make the perineal wound hug the tube. Fix the tube in place with a safety-pin or tapes. Test the patency and efficiency of the drain by irrigating the bladder through it. The end of the tube should reach, but not penetrate far into, the bladder.

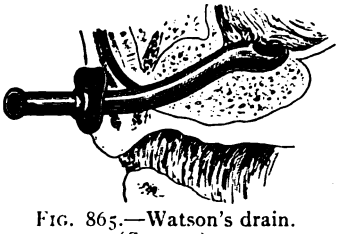

FIG. 865.—Watson's drain. (*Stewart.*)

Return the patient to bed, the upper end of which ought to be elevated slightly. The mattress ought to be firm and not sag under the patient's weight, otherwise drainage will be poor. The perineum is covered by dressings kept in place by a T-bandage through which the drainage-tube emerges. It is easy to attach to the drain a long rubber tube which conducts the urine to any convenient receptacle. After two or three days the drainage-tube must be changed. The time during which drainage must be kept up varies according to the operation performed. After a simple lithotomy the tube should be removed in two or three days and the wound allowed

to heal. In cases of cystitis or posterior urethritis drainage ought to be kept up until the tissues get into a healthy condition.

If in Step 3 forcible digital dilatation fails to give a sufficiency of room, median prostatotomy may be performed. Using the finger in the prostatic urethra as a guide, introduce a probe-pointed knife and with it divide the prostate in the middle line posteriorly. Bleeding may be stopped by pressure from a snugly fitting Watson's drain or by packing the wound with gauze around a stiff gum-elastic drainage-tube. Prostatotomy performed as above is an integral part of some of the procedures for the removal of enlarged prostatic lobes.

As the perineal operations for the removal of vesical calculi (lateral lithotomy, Wood's operation, etc.) are thoroughly described in every text-book on general surgery ("American Text-book;" De Costa; Moullin; Rose and Carless; Parkes, etc.), they will not be treated of here. The same is true of the operation of litholapaxy.

PERINEAL PROSTATECTOMY

A very large number of incisions have been described by which the prostate may be exposed in the perineum. When these are analyzed they resolve themselves into two, each of which may be modified during the operation according to the dictates of common sense.

Method A: Median Incision.—The earlier steps of this operation are identical with those of median perineal cystotomy. When the membranous urethra is opened and the prostatic urethra dilated, pass into the bladder a suitable tractor, and with it pull the prostate downwards into the wound.

Several efficient tractors have been devised for this purpose; the best known are Parker Syms', provided with a dilatable rubber bulb; Young's (Figs. 866, 867), having separable metal blades, and A. H. Ferguson's. In the absence of a special instrument any good stout metal sound answers the purpose.

With scissors or knife incise the fibrous sheath of the prostate; insinuate the finger between the sheath and the gland and enucleate the latter. Sometimes the prostate comes away in one piece, sometimes in two or more fragments. Most surgeons begin the enucleation in the left lobe; this is a mere matter of convenience. "Usually, but not always, the floor of the prostatic urethra is divided when the middle portion is being taken out; but the author has had all his specimens examined by the microscope, and it has been shown that no mucous membrane has been taken away" (except in one case). (Parker Syms, "Brit. Med. Jour.," Nov. 8, 1902.) Drain the bladder by a perineal tube (No. 36 Fr.) fastened to the upper part of the wound. Pack the wound cavity firmly with iodoform gauze. Attach a rubber tube to the drain so as to conduct the urine to a suitable receptacle. Wash out the bladder frequently through the drain. Change the gauze pack after the lapse of twenty-four hours, lessening the amount of gauze used. Encourage the patient to move about in bed and to sit up at the earliest possible moment. This is important. Remove the drain in about one week. After the drain is removed wash out the bladder at intervals by means of a catheter. Occasionally intro-

e a sound to maintain the urethra patent. In operating in much the same ıner as above described, H. Young divides the prostatic capsule external he location of the seminal ducts, and believes he is able to remove a suf- ncy of the gland without destroying these structures. That portion of prostate subjacent to the ejaculatory ducts is not involved in the hyper- hic process and hence can be safely left.

FIG. 866.

FIG. 867.

FIGS. 866 AND 867.—Young's prostatic tractor. (*Young.*)

Another method is as follows: Expose and open the membranous urethra bove; guided by the finger passed through the prostatic urethra divide the tate posteriorly in the middle line with a probe-pointed knife (median tatotomy). Seize the edge of the divided capsule in forceps, and with finger separate the capsule from the gland and shell out the latter *en masse* n pieces. As the enucleation proceeds, it is well to make traction on the s, which are being removed, by means of claw-like sharp retractors. George y, after dividing the prostate as above, pushes his finger into the bladder, nuates it between the prostate and the vesical mucosa and then shells out enlarged lobes from above downwards. Through the urethral wound it is to shell out the middle lobe if it is enlarged, and to remove any vesical uli which may be present. In cases where enucleation with the finger is

difficult some surgeons extripate by *morcellement*, cutting the gland away piecemeal with scissors or rongeur forceps; when this is done, it is advised to begin the extirpation remote from, and work towards, the urethra.

Method B: Transverse Incision.—Zuckerkandl was probably the first to advocate this method of exposing the prostate. The whole operation has been well systematized by Albarran. Very many operators have devised various modifications in details, using incisions of divers shapes, **H, Y, V,** etc., to increase the exposure of the prostate. Practically, any one of these cuts give as good results as any other.

Prepare the patient as already described and place him in the lithotomy position with the pelvis well elevated. This posture, a combination of the Trendelenburg and lithotomy positions, is of very great service, being almost essential. Introduce a sound or staff into the bladder and entrust its handle to an assistant.

Step 1.—One fingerbreadth in front of the anus make a slightly curved (concavity posterior) transverse incision through the skin and subcutaneous tissue, from one ischial tuberosity to the other.

Step 2.—Guided by the sound in the urethra expose its membranous portion and bulb. Catch the tissues on each side of the bulb with volsella forceps and so pull the bulb upwards out of the way and at the same time steady the perineum. Do *not* open the urethra. Introduce a finger of the left hand (protected by a rubber glove) into the rectum, and with the right hand separate the rectum from its anterior connections—*i.e.*, from the prostate. This may be done by blunt dissection, aided by an occasional cut with scissors. If the surgeon keeps close to the prostate, this step is easy. The finger in the rectum saves injury to that structure. Introduce a broad, flat, long-bladed retractor into the wound and pull the rectum and posterior surface of the wound backwards, exactly as the vagina is retracted in operations on the cervix uteri.

Step 3.—Make the assistant turn the beak of the sound backwards so as to lie behind the middle lobe of the prostate and pull it down into the wound as much as possible. Instead of a sound Young's (Figs. 866 and 867) or Ferguson's prostatic tractor may be used. The prostate now lies exposed.

Step 4.—Split the prostatic capsule by a transverse or vertical incision as may be convenient. If it is desired to save that portion of prostate corresponding to the urethral floor, make a longitudinal cut on each side through the capsule. Seize the edges of the wound in the capsule with forceps and with the finger insinuated beneath the capsule enucleate the gland. As the enucleation proceeds pull on the part being removed with claw-shaped retractors. If the urethra is accidentally torn, the middle lobe when enlarged can be easily reached and enucleated with the finger. The accident to the urethra does not seem to be of much moment. If the urethra is not opened and a projecting middle lobe is present, it can be reached and removed with the finger through the prostatic wound.

Step 5.—Partially close the deep wound with sutures. Introduce a drain into the bladder and firmly pack the wound with iodoform gauze.

It will be seen that, except in the matter of exposure, the operation by

transverse incision is almost identical with that by median. Undoubtedly by the transverse method a much better exposure of the field of operation is obtained, at the expense of a little more trauma, but most of the actual work is done by the finger unguided by the eye, hence the improved exposure is not of so much value as might appear at first glance.

All the operations here described are carried out inside the capsule; extra-capsular operations have been devised and described, but they occasion so much shock and hemorrhage that they are unsuited to the extirpation of benign neoplasms. While none of the methods described can be truly named complete prostatectomies, yet they approach so nearly to completeness that they may be termed so for the sake of convenience and to distinguish them from the next class of operations, which are frankly incomplete. Rydygier, Riedel, and others frequently expose the prostate by the transverse incision and content themselves with excising portions of the lateral lobes, opening neither the urethra nor the bladder. The result of taking away such portions of the prostate is that pressure is removed from the prostatic urethra, and as the wounds heal and contract, the urethral lumen is widened. The method is less severe than the more complete operations and has given good results even in cases in which the middle lobe has been enlarged. Of course, the operation is meant primarily for cases of hypertrophy of the lateral lobes and it has a distinct field of usefulness.

Radical Prostatectomy for Cancer.—Young has described a method of removing the prostate for cancer ("Johns Hopkins Bulletin," Oct., 1905; "Annals Surg.," Dec., 1909) which he carried out in six cases. One of the patients was alive and well four and a half years and another six months after the operation. The operation is only suited to cases in which the disease is well limited to the prostate or at least does not extend more than a short distance beneath the trigone.

The Operation.—Steps 1, 2 and 3.—Place the patient in the exaggerated lithotomy position. Expose the membranous urethra and prostate by an inverted V-incision. Proceed as in prostatectomy by the transverse incision (Method B, Steps 1, 2, 3, p. 708) until the prostatic tractor is put in place and the posterior surface of the prostate has been exposed, largely by blunt dissection. If there is any doubt as to diagnosis, incise the capsule and remove a segment of gland for immediate microscopic examination.

Step 4.—Free the lateral adhesions of the prostate and also the seminal vesicles as much as possible by blunt dissection. Divide the membranous urethra in front of the tractor.

Step 5.—Depress the handle of the tractor markedly and divide the pubo-prostatic ligaments close to the prostate after pushing away the anterior plexus of veins. Hemorrhage must be controlled by clamps and by a gauze pack held tightly against the posterior surface of the pubes and the triangular ligament by means of a retractor. At this time the seminal vesicles may be further freed.

Step 6.—Pull the prostate as far as possible out of the wound, thus exposing the anterior wall of the bladder. Open the bladder by a transverse incision close to its junction with the prostate. Enlarge the incision until the trigone is

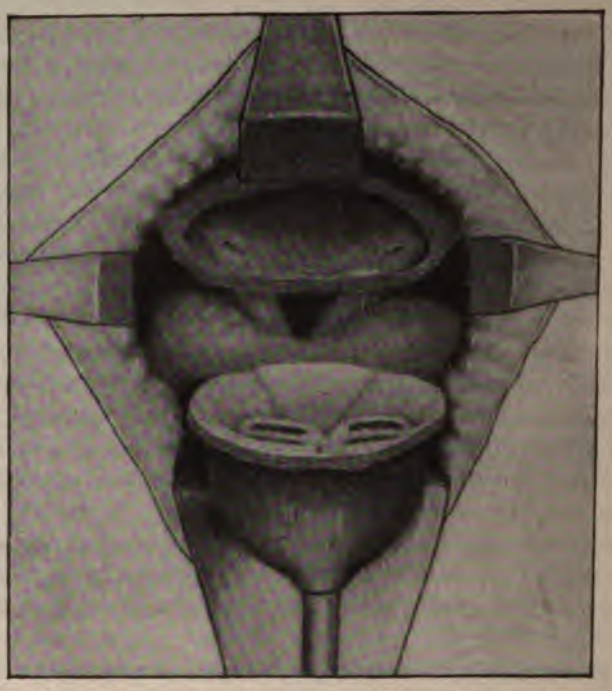

FIG. 868.—Prostatectomy for cancer. (*Young, Annals of Surg.*)

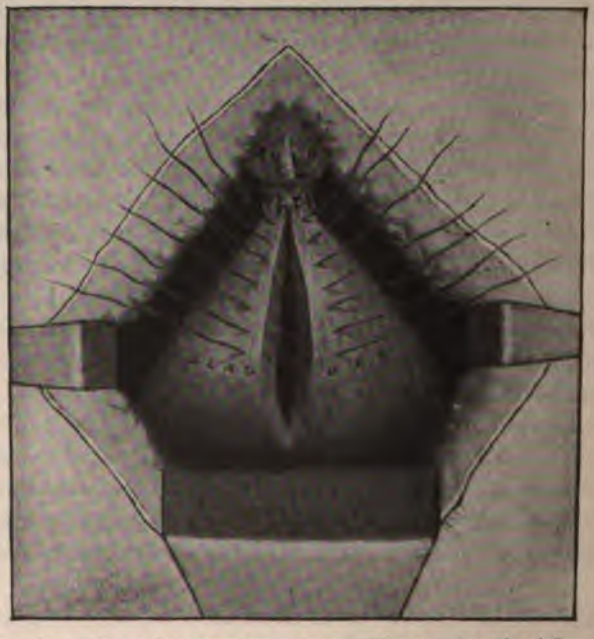

FIG. 869.—Prostatectomy for cancer. (*Young, Annals of Surg.*)

well exposed. (Fig. 868.) With a scalpel continue the transverse cut in the bladder across the trigone, leaving the upper angles of the trigone intact and the ureters uninjured. By blunt dissection through the wound in the bladder complete the exposure of the seminal vesicles, pick up the vasa deferentia and divide them as high as possible. Remember that the vasa deferentia pass around the lower end of the ureters which must not be injured.

Step 7.—Separate the deep attachments of the seminal vesicles, controlling the resulting bleeding by clamps and ligatures. Remove the prostate, seminal vesicles, and about 5 cm. of the vasa deferentia in one piece.

Step 8.—Pull the anterior wall of the bladder down and form an anastomosis between the anterior part of the bladder wound and the divided membranous urethra, using catgut for sutures. (Fig. 869.) Close the rest of the vesical wound by catgut sutures. Introduce through the penis a retention catheter.

Step 9.—Approximate the levator ani muscles with catgut sutures. Partially close the skin wound after providing for drainage.

McKillop's Operation (Med. Journ. of Australia, Jan. 18, 1919). *Step* 1.—Distend the bladder with Boracic lotion (6 or 8 oz.). Leave the catheter in position. Make a median incision from the pubis upwards for 2 to 3 in. Push the peritoneal reflection upwards. With gauze clear the space of Retzius until the muscle wall of the bladder is exposed. Pack the space of Retzius firmly with gauze so as to push the bladder well down toward the perineum. With sutures close the wound completely over the gauze pack.

Step 2.—Place the patient in the lithotomy posture. Make the usual transverse perineal incision until the perineal muscles are exposed. Open the plane of cleavage between the rectum and prostate which lies low because of the pressure in the space of Retzius. Expose the false or fascial capsule of the prostate and dissect externally to the capsule. Pressure over the hypogastric pack brings the prostate almost flush with the perineum so that bleeding can be controlled under guidance of the eye. Divide the pubo-prostatic and true lateral ligaments of the bladder. Hook the finger above the fascial capsule and separate the gland from the base of the bladder external to the internal sphincter.

Step 3.—Excise the prostate and its fascial capsule by cutting it from the bladder (the line of section being in bladder tissue) and by dividing the *vasa deferentia* and the membranous urethra with its contained catheter.

Step 4.—Introduce a fresh catheter. Attend to hemostasis. Close the redundant bladder wound with catgut sutures which must not penetrate the mucosa.

Introduce a gauze drain covered by a split rubber tube to the bladder wound and pack iodoform gauze around this firmly. Suture the lateral portions of the perineal wound.

Step 5.—Reopen the suprapubic wound; remove the gauze pack and close the wound again after providing for drainage.

After treatment.—Change the perineal pack after 48 hours. Remove the

split tube on the fourth day. Change the catheter daily after the first week. Later pass sounds.

McKillop writes the author that his four patients survived operation and that one was alive four years and one two years after operation, both having a fair degree of urinary control.

Diverticula of Urinary Bladder.—The method of operating varies with the site of the diverticulum.

1. The diverticulum is situated on the anterior surface or the side of the bladder. Expose the bladder through a transverse or a median incision. Do *not* open the peritoneum but push it aside until the diverticulum is exposed. Excise the diverticulum and treat the wound in the bladder as described on p. 681.

2. The diverticulum is on the dome of the bladder and cannot be exposed extra-peritoneally Open the abdomen. Protect the peritoneal cavity thoroughly with pads. Excise the diverticulum. Close the vesical wound and provide for drainage as described on p. 692. As the diverticulum is always the seat of severe infection it might possibly be better to operate in two stages: (*a*) bringing the diverticulum and part of the vesical wall into the abdominal wound and suturing the parietal peritoneum to the bladder around the diverticulum; (*b*) after the peritoneum has become protected by adhesion, excising the diverticulum and closing the vesical wound.

3. The diverticulum arises from the posterior wall of the bladder and lies between the bladder and rectum.

Graser (Kreuter, Zent. f. Chir., Nov. 8, 1913, p. 1740) operates as follows:

Step 1.—Drain and explore the bladder suprapubically. With a sound in the diverticulum and a finger in the rectum the size and location of the lesion is easily defined.

Step 2.—Place the patient in the combined Trendelenburg and lithotomy position. Make a curved transverse incision (concavity posterior) from one ischial tuberosity to the other. Guided by a sound in the urethra, expose the membranous urethra and the prostate. A finger in the rectum is an essential aid in orientation. Separate the rectum from the prostate and bladder until the diverticulum is reached. Because of past and present inflammation the diverticulum is firmly adherent to its surroundings. Remove the finger from the rectum and change gloves. Open the diverticulum. With a finger in the diverticulum as a guide, separate it from its surroundings by blunt and sharp dissection, pushing the peritoneum out of the way.

Step 3.—Excise the diverticulum and invert its stump into the bladder by means of stitches, being careful not to injure or occlude the ureter.

Step 4.—Thoroughly drain the perineal wound. Provide for suprapubic drainage.

INFRAPUBIC PROSTATOTOMY AND CYSTOTOMY

The prostate and lower part of the bladder may be exposed immediately under the pubic arch. This route avoids the neighborhood of the anus, with its ever present infection, while it gives more direct access to the prostate and

better drainage than does the suprapubic route. If the patient is feeble, the operation may be done in two sittings, the first consisting of the exposure of the prostate, the second of the prostatotomy or prostatectomy. (L. Heusner, "Centralblatt f. Chir.," 1904, p. 217.)

Step 1.—Make a curved incision through the skin along the lower margin of the pubis and its descending rami.

Step 2.—Divide the insertion of the suspensory ligament of the penis, the corpora cavernosa; the ischio-cavernosus muscle, the triangular ligament, and part of the insertion of the adductor muscles. With a chisel or rongeur forceps cut away about half of the symphysis pubis and of the descending rami. Separate the prostate from the posterior surface of the pubes. When this is done, it is easy to pull the prostate downwards and expose its whole anterior surface. Bleeding from the plexus of veins anterior to the prostate is liable to be considerable. If this cannot be sufficiently controlled to permit of further progress, or if, as in Heusner's case, the patient is too weak, it is easy to pack the wound and resume the operation after the lapse of a few days.

Step 3.—Pass a sound into the bladder *per urethram*. Using the sound as a guide, split the prostatic urethra through its whole extent along its anterior or ventral surface. This exposes the prostate exactly as in a postmortem.

Step 4.—Remove all obstructing lobes exactly as is done when other methods of exposure are employed. If it is desired to open the bladder instead of the prostate, this is easily accomplished by the removal of more bone from the pubis. The operation is, however, much more suitable for prostatic than for vesicular disease.

Step 5.—Close the wound in the prostate with a few catgut sutures. Provide for drainage. Close the skin-wound.

Vesiculotomy.—Vesiculectomy has been performed a number of times but the results have not been encouraging and the operation will not be described here. The chronicity of many urethral infections is often due to involvement of the seminal vesicles, and for the treatment of these lesions Eugene Fuller has advised emptying the vesicles by stripping them with the finger introduced *per rectum*. This treatment must necessarily be kept up for months. The same surgeon, in inveterate cases, advises drainage of the vesicles by means of vesiculotomy. In view of the importance of obscure infections in the etiology of the so-called rheumatisms, etc., the subject of vesiculotomy has become one of distinct moment, though the operation can scarcely be expected to become as fashionable as has the removal of adenoids and of more or less innocent tonsils in the treatment of rheumatism.

Fuller's Vesiculotomy (N. Y. Med. Record, Oct. 30, 1909).—Thoroughly empty the large bowel by means of purgatives and enemata. Place the patient in the knee chest position, the hips being well flexed and abducted, the knees being flexed. The services of two attendants are requisite to keep the patient in correct position.

Step 1.—Beginning at a point near the base of the coccyx, and just inside the body of the ischium, make an incision past the *tuber ischii* to end at a point about ¾ inch external and about ¾ inch anterior to the anterior border of

the anus. Make a similar incision on the opposite side. Unite these two incisions by a transverse cut crossing the perineum (Fig. 870).

Step 2.—Through the lateral incisions divide a few of the lower fibres of the gluteus maximus muscles and penetrate the fat of the ischio-rectal spaces. Through the transverse cut divide the anterior layer of the deep fascia but carefully avoid injuring the anal sphincter.

Step 3.—With the forefinger of the left hand in the rectum as a guide separate the rectum from the prostate and seminal vesicles by means of blunt dissection with the right forefinger. "All the while the right forefinger tip is peeling the rectal wall off from the lower structures, the left forefinger tip maintains its position in the rectum, guiding, as it were, the lower finger in its work and preventing it from directing the dissection pressure against the rectal wall, thus endangering perforation. As the rectal wall only separates these two fingers, it is easy to appreciate the distinctness with which the left finger tip can feel the right as it accomplishes its work of separation. The rectal wall having been thus separated from the seminal vesicles the left forefinger is withdrawn from the rectum while the tip of the right forefinger is maintained in the dissection and made to press gently but firmly over the apex of the right seminal vesicle. A long, grooved director is next passed by the free left hand along and under the right forefinger until the end of the instrument reaches the apex of the right seminal vesicle and lies just under the right finger tip. The left hand then holds the director firmly in that position, while the right forefinger is withdrawn. The right hand then takes a scalpel, the blade of which is passed along the groove of the director until the point of the knife enters the apex of the seminal vesicle. After the point has so entered, the shaft of the scalpel is lowered and a free cut of about 1¼ to 1½ inches is made with the belly of the blade along the course of the seminal vesicle, freely laying open the cavity of the organ. This cut is made with the belly of the blade rather than with the point of the scalpel, for if made with the point the incision might be accidentally too deep, the floor of the bladder being opened. The incision so made is then divulsed with the finger tip, thus widely opening the sac cavity. By an exactly similar procedure the cavity of the left seminal vesicle is next opened. The cavities thus opened can be exposed with the finger tip and, if found filled with granulation tissue, curettage can be employed. Oftentimes the finger nail may be most efficient for this purpose, although, in advanced instances, a sharp steel instrument may be necessary. Seminal vesiculotomy is not a bloody operation, no vessels, as a rule, of sufficient size to require a ligature being encountered. The cavities of the seminal vesicles so opened are each separately packed with gauze, the end of each packing being left protruding from the external wound. Two soft rubber drainage tubes are then placed between the gauze packing and the rectal wall. The lateral edges of the incision are next brought into natural apposition by sutures, the

FIG. 870.

transverse portion of the cut only being left open for the ends of the drainage tubes and the gauze packing. In the after-treatment no irrigation into the ends of the tubes is advisable. The gauze is removed at the end of the fifth day; the drainage tubes at the end of the ninth or tenth day. The bowels are moved daily, to guard against rectal fecal distention. In some cases urinary retention follows operation; consequently, the surgeon should be prepared to have a soft catheter passed if necessary. There is generally little systemic disturbance after this operation. A bulky gauze dressing held in position by a T bandage is the form of external dressing employed. The operation generally necessitates a stay in a hospital of three weeks, the first two weeks being in bed."

CHAPTER LI

URETHRAL STRICTURE

Meatotomy.—As a preliminary to the introduction of urethral sounds it is often necessary to enlarge the meatus.

Introduce a probe-pointed knife into the urethra for a distance of about ¾ inch, *i.e.*, to a point immediately behind the meatal narrowing. Cut in the middle line below, but do not cut completely through to the external surface, otherwise a hypospadias will be produced. The after-treatment consists in keeping the wound open by passing a sound or a glass rod at frequent intervals.

Internal Urethrotomy.—*Preparation of Patient.*—Somtimes it is wise to prepare the patient by administering urotropin or its equivalent for a day to two before operation. Immediately before operating wash the penis and especially the glans with soap and water, cover the thighs and abdomen with sterile towels, irrigate the urethra (and if possible, the bladder) with a mild antiseptic solution or with warm salt solution. Inject into the urethra a drachm or two of sterile olive oil and immediately proceed to operate.

There are two types of operation: (A) in which the stricture is divided from before backwards; (B) in which the division is from behind forwards. The latter method presupposes that the stricture is not a narrow one or that it has been already dilated sufficiently to admit the passage of the urethrotome. Of the two types of operation there are many varieties, but only the typical procedures will be described here. The number and varieties of urethrotomes are legion. Their description would take up much space and serve no useful purpose.

A. *Division of the Stricture from Before Backwards.*—Prepare the patient as above. Determine, if possible, the site and extent of the stricture or strictures by means of a *bougie a boule*. Introduce through the stricture a soft filiform bougie the proximal end of which is fitted with a screw. Screw the distal end of a Maisonneuve urethrotome (Fig. 871) to the filiform gui[de]. Push the urethrotome along the urethra, the knife blade being in contact w[ith] the middle of the roof of the urethra. The knife blade being blunt at its ap[ex] cannot cut the normal urethra, but its distal edge being sharp cuts the stric[ture]

ture when it comes against it. Having divided one stricture, remove the urethrotome and explore the whole urethra so as to find if other stenoses are present. The urethra should now admit a full-sized sound.

B. *Otis' Operation: Division of the Stricture from Behind Forwards.*—Preparation and exploration of the urethra as already described. Introduce an Otis' urethrotome (Fig. 872) through the stricture. By means of the screw at the proximal end separate the blades of the instrument until the tissues of the stricture are put on the stretch but not torn. Up to this time a knife blade

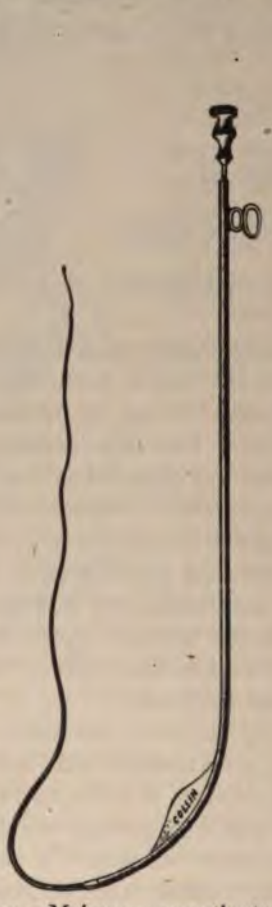

FIG. 871.—Maisonneuve urethrotome.

FIG. 872.—Otis urethrotome.

lies concealed at the distal end of the urethrotome. By using the proper mechanism, make the knife blade protrude and cut through the stricture in the middle line above. Sheath the knife blade again. Complete the dilatation of the stricture by separating the blades of the urethrotome until the urethra is large enough to admit a full-sized sound. Remove the urethrotome. Explore for the presence of other strictures.

Complications and Dangers of Internal Urethrotomy.—1. *Hemorrhage.* By cutting in the middle line above, the least vascular region is incised. The stricture itself is sclerosed, non-vascular fibrous tissue, hence severe bleed-

ing is not common. When serious bleeding arises it may be controlled by the passage of a full-sized catheter, and if necessary by exercising pressure from the outside on the urethra which is now supported by the catheter.

2. *Urethral Fever.*—This is usually a form of septic intoxication due to the absorption through the urethrotomy wound of septic products already existing in the urethra or being discharged with the urine. Septicemia or pyemia are rare. *Methods of avoiding urethral fever:* (*a*) Preliminary exhibition of substances (*e.g.*, urotropin) calculated to improve the condition of the urine. (*b*) Rigid asepsis. (*c*) König advises to irrigate the bladder with a mild antiseptic solution as soon as the operation is completed and to leave in the bladder a few ounces of the solution. This dilutes and favorably affects the urine so that noxious substances are not absorbed from it when it is next voided.

Irrigation of the urethra during convalescence is rarely necessary.

After-treatment.—The patient ought to be kept in bed for a few days. If there is retention of urine a soft rubber catheter must be passed. Catheterization may often be voided by applying moist heat to the perineum and hypogastrium, or by placing the patient in a hot bath with instructions to urinate in the water, if he can.

After a lapse of five to seven days pass a full-sized sound into the bladder. Before this can be done successfully it may be necessary to pass a number of smaller instruments of increasing size. Repeat the passage of sounds at intervals of two or three days. The daily passage of sounds irritates and is useless. The interval is to be gradually increased until a cure or practical cure is obtained.

External Urethrotomy.—Prepare the patient as for internal urethrotomy. In addition scrub and shave the perineum. Clean the scrotum and the adjacent portions of the buttocks and thighs. Explore the urethra and locate the stricture. Put the patient in the lithotomy position.

FIG. 873.—Syme's staff.

A. *Operation with a Guide.*—Various instruments may be used as guides The best is probably the Syme's staff (Fig. 873). Filiform whalebone bougies serve the purpose well and are more commonly obtainable.

Step 1.—Pass the guide into the bladder. If Syme's instrument is used the thin portion passes through the stricture, the thick portion serves as a guide to the urethra on the meatal side of the stricture. If the whalebone filiform is used, pass alongside it or looped on it (like Gouley's sounds) a large metal sound down to the face of the stricture. Let an assistant hold the sound steadily in the middle line of the body and make its point press towards the skin of the perineum. Retract the scrotum upwards.

Step 2.—Palpate the perineum and feel the point of the sound. In the

middle line make an incision down to the point of the sound. This opens the urethra immediately anterior to the stricture. Retract the edges of the urethral wound with sharp hooks, fine volsellæ, or with a couple of fine sutures introduced for the purpose. Withdraw the metal sound. If Syme's guide is used leave it *in situ*.

Step 3.—If possible pass a fine grooved director along the guide and with a knife split the stricture completely. If it is impossible to introduce a grooved director cut down upon the guide from in front backwards until the whole stricture is divided. It is convenient at this stage to pass through the perineal wound a probe-pointed Teale's gorget (Fig. 874) into the urethra posterior to the stricture. The gorget acts as a guide to the full-sized sound or catheter which must now be passed through the urethra into the bladder. The use of the gorget is not necessary.

There are many modifications of the above operation, most of them requiring special instruments. For a description of such see treatises on genito-urinary surgery. The operation as described has served the author well.

FIG. 874.—Teale's gorget.

B. *Operation Without a Guide.*—Prepare as described above.

Step 1.—Pass a metal sound down to the face of the stricture. Have it held by an assistant accurately and steadily in the middle line.

Step 2.—Incise the perineum, expose the sound, and retract the edges of the urethral wound as in the preceding operation. Remove the sound.

Step 3.—Examine carefully the face of the stricture with the eye and a fine probe for an opening through it. Remember that the opening may be in any position on the face of the stricture. The search may be aided by making a little pressure on the hypogastrium, and so forcing some urine along the urethra and out through the stricture, where its point of emergence should be noted. If it is possible to find the passage through the stricture and to introduce a probe the operation becomes identical with that in which a guide is used. If the introduction of a probe is impossible proceed as follows:

Incise the stricture longitudinally exactly in the middle line until the healthy urethra is reached posterior to the stricture. If this is not promptly accomplished, do *not* waste time and lacerate the tissues by making more incisions in the stricture tissues, but boldly endeavor to incise the urethra posterior to the stricture, always cutting in the middle line. When the urethra is opened at this point it is easy to cut through the stricture and pass a sound from the meatus past the perineal wound into the bladder. If the posterior urethra is not easily found during the above procedure do *not* spend much time looking for it, as such a search may do much damage. Open the bladder above the

pubis and pass a sound through the bladder to the perineum (retrograde catheterization). The point of this sound acts as a guide and makes incision of the urethra easy. The value of abstention from much burrowing in the perineum and of retrograde catheterization is insisted on, as the author has seen much damage result from the former and no harm from the latter procedure.

After-treatment.—Immediately after the operation irrigate the bladder. Stop all hemorrhage. .Two methods of attending to urination are now possible:

(*a*) Apply a gauze pad to the perineal wound and permit the urine to escape either through the meatus or through the perineum, as it pleases. In one of the author's cases hardly a drop of urine escaped through the wound.

(*b* Introduce a catheter (Pezzer self-retaining catheter is best) through the wound into the bladder and keep it there. It is easy to connect the catheter to a long tube and so drain the urine into some convenient receptacle.

Keep the perineal wound clean and frequently change the dressings. Some simple antiseptic ointment applied to the surrounding skin gives comfort and lessens scalding. After the lapse of five to eight days pass a sound through the meatus into the bladder. This is usually difficult. The writer has more than once found a spur in the depth of the perineal wound which rendered the passage of the sound impossible. Division of the spur was all that was necessary. The spur itself was undoubtedly the result of insufficient division of the stricture at the primary operation.

Repeat the passage of the sounds at constantly increasing intervals until a cure is effected. The perineal wound heals rapidly unless some strictures exist in the urethra anterior to it.

Urethrectomy: Excision of Stricture.—Complete urethrectomy is comparatively rarely indicated; it means excision of the whole *circumference* of the urethra. Incomplete urethrectomy is the usual operation; in it a portion of the dorsal wall of the urethra is preserved. The preservation of even a small strand of dorsal wall is of much importance, as it aids marvelously in securing apposition and acts as a guide in catheterization.

Perineal Urethrectomy.—*Step* 1.—Prepare the patient and open the urethra as in external urethrotomy.

Step 2.—If not already done, pass a sound or probe through the stricture. With forceps, knife, and scissors carefully and thoroughly remove every particle of the contracted and deforming scar tissue from the under and lateral side of the urethra, but preserve, if at all possible, a portion of the upper wall of the urethra. It is necessary to remove all the diseased tissue.

Step 3.—*Restoration of the Urethra.*—(*a*) Introduce through the penis to the bladder a retention catheter. Make an end-to-end union over the catheter of the divided urethra by fine, interrupted catgut sutures which do *not* penetrate the mucosa. To avoid stenosis it is necessary to incise longitudinally the floor of each segment to be united and convert the longitudinal into transverse wounds when suturing (Fig. 875, AA′, BB′). Be sure that each stitch has a firm hold. Either close the superficial perineal wound with sutures or permit it to heal by granulation.

(*b*) Hartmann usually introduces a retention catheter and over it closes the wound with fine catgut sutures which do *not* penetrate the mucosa, but

grasp all the perineal tissues except the skin. The skin wound he leaves open (Fig. 876).

Methods *a* and *b* are only useful when the separation of the two segments of urethra is not more than about 1½ inches (3 to 4 centimeters).

(*c*) When the urethral defect is very great, treat as after external urethrotomy. When all the diseased tissue has been excised the wound heals readily and rapidly, leaving a scar which is much softer and less liable to contract disastrously than if diseased tissue has been left (Hartmann).

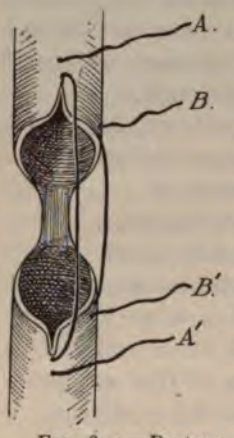

FIG. 875.—Restoration of urethra after urethrectomy.

After-treatment.—Remove the retention catheter on the eighth day. On the twelfth day begin passing sounds.

Russell's operation (R. Hamilton Russell, Brit. J. Surg., II, p. 375) promises to supersede all others. The male urethra can be slit up from the membranous portion to the meatus (the scrotum being split at the same time) and healing will take place without stricture provided that efficient perineal drainage of the bladder is secured during healing. The urethra under the above circumstances is changed from a tube of mucosa into a ribbon of mucosa and if left alone, its edges flanked on either side by raw tissues which tend to fall together and cohere, will, when this has taken place, be of necessity reconverted into a tube.

Step 1.—place the patient in the extreme lithotomy postion with the pelvis well raised. Make a Λ-incision having its apex at the central point of the perineum and open the ischio-rectal fossa on each side. Detach the external anal sphincter from the bulbo-cavernous muscle at the central tendon. Retract the sphincter backwards with a bifid retractor. Pull forwards the bulb of the urethra and the transversus perinei muscles thus exposing the membranous urethra and the apex of the prostate exactly as in perineal prostatectomy. Open the membranous urethra longitudinally and introduce a silk thread tractor into each side of the wound. Split the urethra forwards to the stricture.

Step 2.—Pass a guide or sound through the meatus to the face of the stricture and on it open the urethra longitudinally in front of the stricture, through a median cut which meets the apex of the first incision. Introduce silk tractors into the sides of this urethral wound and slit the urethra back to the stricture. The stricture now lies exposed, with an inch or two of split open urethra both behind and in front of it.

FIG. 876.—Suture of urethra.

Step 3.—Excise the stricture along with the surrounding extra-urethral masses of scar tissue. This must be done thoroughly, but no more healthy mucosa sacrificed than is absoutely necessary. Mobilize the divided ends of the urethra by undercutting and unite them by five sutures of fine catgut.

Step 4.—Pass a catheter through the perineal wound into the bladder and anchor it with sutures. Close the lateral perineal wounds with deep silkworm-gut stitches. Do not place any sutures in the perineum in front of the catheter. After about one week the catheter may be removed and the per-

ineal wound permitted to heal. Several weeks after healing has taken place pass full sized sounds. The occasional subsequent passage of a sound is an advisable precaution.

In a case in which "a very bad stricture in the bulbous urethra was complicated by multiple strictures in the penile portion, I slit up the urethra from the membranous portion to within an inch of the meatus, dividing, of course, the scrotum. The stricture of the bulb was excised, and the penile strictures treated plastically. No special sutures were put into the urethra other than those at the seat of excision; only in the penile portion the lateral margins of the urethra were caught up and approximated by inclusion in the skin sutures. The skin and scrotum were sutured, and healing took place uneventfully throughout. A full-sized instrument was easily passed for the first time five weeks after the operation" (Russell).

Penile Urethrectomy.—Apply an elastic constrictor to the root of the penis.

Step 1.—Make a longitudinal median incision to expose the stricture. Excise the *whole* cicatricial node, even, when requisite, removing part of the corpora cavernosa.

Step 2.—Suture the urethra with fine catgut sutures which do not penetrate the mucosa. Suture the cavernous and spongy bodies according to necessity. Remove the elastic constrictor so as to observe and control hemorrhage. Close the skin wound.

Step 3.—Open the perineal urethra and through this wound introduce a self-retaining catheter to keep the penile urethra from being irritated by the passage of urine.

Remarks.—Urethrectomy gives better results than external urethrotomy, but it rarely results in a radical cure. Subsequent passage of sounds remains necessary in most cases.

R. Mühsam ("Berlin. klin. Woch.," 1912, No. 12) (Ref. "Zentralblatt für Chir.," 1912, No. 23) excised an impermeable stricture 6 cm. in length and substituted for it 8 cm. of the long saphenous vein. The vein was drawn over a catheter (valves facing distally) and sutured with precision to the urethral stumps. The result was good.

Rupture of the Urethra.—Operative treatment of urethral rupture varies greatly according as the case is seen early or late, when infection and necrosis have taken place. Practically every case of urethral rupture demands prompt operation. It is rarely possible to introduce a catheter beyond the site of rupture; even when this is possible perineal section ought to be performed to evacuate effused blood and provide free drainage.

I. *Early Operations.*—Lithotomy position. Clean the perineum and its surroundings. Pass a sound through the penis down to the site of rupture. Expose the injured urethra exactly as in external urethrotomy. Find the opening into the posterior segment of the urethra. This may be easy but is often extremely difficult. If, after reasonable search in the well retracted wound aided by reflected light and the use of probes, etc., the posterior urethra cannot be found, it is usually advised to incise in the median line further back, and so enter the intact portion of the posterior urethra and, by means of a probe passed from behind forwards, find the desired orifice. To the author it seems much better, under the above circumstances, to open the bladder above the

pubis, practise retrograde catheterization, and subsequently drain or siphon the urine through the suprapubic wound.

When the site of injury has been well exposed, blood clots evacuated, injured shreds of tissue removed, the urethral wound may be (*a*) closed as after urethrectomy or (*b*) drained as after external urethrotomy.

If, when the patient is seen, he is in very poor condition from shock, do *not* immediately operate as above. Either evacuate the urine from the bladder by suprapubic aspiration and await reaction, or, guided by a sound passed into the urethra, cut down to and freely open the urethra at the site of injury, and making no search for the posterior opening into the urethra, trust to simple drainage. Simple drainage has stood the writer in good stead.

II. *Late Operation.*—Late operation, *i.e.*, operation after there is much infiltration of urine, distinct infection and necrosis of tissues, resolves itself into the treatment of the urinary infiltration and phlegmonous inflammation.

The operation is identical whether the trouble is due to a neglected traumatic rupture or to neglected stricture, etc.

A sound passed per urethram to the site of injury may be an aid; it is not a necessity, as the aim of the surgeon at this time is not to definitely open the urethra but to open the collections of pus, urine, etc., *in the tissues.* The urine will escape sufficiently through the opened abscesses. In the cases under consideration (only a few hours may have elasped since the accident) the scrotum, penis, and perineum are usually very much swollen.

Lejars writes: "Don't try to catheterize. Don't waste time by making haphazard and insufficient incisions in the most œdematous zones; at once attack the perineum."

The Operation.—Lithotomy position. Cleanse and shave the perineum and surroundings. Retract the scrotum upwards. Make a median perineal incision about 1½ to 2 inches long. The posterior end of the incision must be at least one fingerbreadth from the anus to avoid injury to the sphincter. Continue deepening the incision until urine and pus escape freely. On account of the swelling, it may be necessary to penetrate 2 inches or more. Always keep to the middle line and persist until the fluid is found. Lejars makes the above incision with the thermocautery; the author has always used the knife.

When the urine and pus are found, explore with the finger and open up subsidiary cavities. If necessary make counter openings Puncture or incise freely all greatly swollen regions, *e.g.*, on the scrotum and penis. Apply plentiful moist dressings. When the swelling and inflammation subside, incisions which at first seemed enormous become almost invisible. The whole operation consists in making (*a*) free primary perineal incision, (*b*) free subsidiary incisions wherever necessary. It is better to make too many and too free incisions than too few and too small.

Late Operation in an Unusual Form of Urinary Infiltration.—When the urine escapes behind the triangular ligament, the territories infiltrated are the pelvis, the ischiorectal fossæ, and the hypogastrium. The penis, scrotum, and perineum are unaffected. The operative treatment required consists in free median incision above the pubis, in free opening of the ischiorectal fossæ, and in drainage of the bladder.

CHAPTER LII

EPISPADIAS

Epispadias is closely allied to hypospadias, and when there is curvature of the organ from fibrous tissue contraction this must be corrected in the same fashion as in hypospadias.

Thiersch's operation is performed in several stages:

I. Construction of urethra in the glans penis. Parallel to the groove in the glans make two incisions, as shown in Fig. 877, *a* and *b*. Lay a glass or metal rod along the groove, and with it depress the groove, at the same time sliding the lateral portions of the glans (mobilized by the two incisions) over the rod, and unite their raw surfaces by quill sutures (Fig. 877, *c*). When the balanic urethra is safely and firmly established and the wounds healed, proceed to

FIG. 877.—Thiersch's operation. (*Esmarch and Kowalsig.*)

II. Construct the penile urethra. Make the skin-flap *a* (Fig. 878) along the whole length of the urethral groove and with its base next the groove. Make the similar skin-flap *b*, with its base remote from the urethral groove. Turn the flap *a* over so that it covers, and has its skin surface next to the groove. With a few points of suture fix the cut edge of flap *a* to the under or raw surface of flap *b*, near its base (Fig. 878). Pull flap *b* over flap *a* and suture its free edge to the raw surface on the penis left by the elevation of flap *a* (Fig. 879). In tracing out the two flaps *a* and *b*, the former is made narrower than the latter.

III. A small opening still exists between the new-formed tubes in the penis and glans. In epispadias the incomplete but usually redundant prepuce hangs below the glans. Make a transverse hole through the prepuce near its base (Fig. 879, *c*, *c*) and push the glans through it. The prepuce now lies on the top of the penis, and by suturing the edges of the wound in it to the vivified edges of the urethral defect, the latter can be closed (Fig. 880).

IV. A defect remains at the base of the penis. To close this, vivify the edges of the defect, and forming a flap (Fig. 881, *a'*), turn it over and suture its edges to the edges of the defect, thus providing an epidermal lining to the portion of the urethra covered. Another skin-flap (Fig. 881, *a*) is reflected and made to cover the exposed raw surface of flap *a'*. This procedure is objectionable in that the skin-flap *a* will assuredly develop hair and cause trouble.

It is far better to cover the opening with a single flap—raw surface inwards—as Cheyne recommends. The contraction which subsequently occurs is far less objectionable than the growth of hair inseparable from Thiersch's plan.

FIG. 878.

FIG. 879.

FIGS. 878 AND 879.—Thiersch's operation. (*Esmarch and Kowalzig.*)

FIG. 880.

FIG. 881.

FIGS. 880 AND 881.—Thiersch's operation. (*Esmarch and Kowalzig.*)

As is stated in the chapter on "Hypospadias," all operations which provide an epidermal lining for the new urethra from skin in which hair is liable to grow are very objectionable, hence Rosenberger's ingenious and simple operation is to be condemned and will not be described.

The Van Hook-Mayo operation for hypospadias is entirely suitable in cases of epispadias.

Cantwell's Operation.—This most ingenious and logical operation ("Annals Surg.," Dec., 1895) seems to have been unaccountably overlooked. The author is indebted to Wetherill for drawing his attention to it.

Step 1.—Open the bladder through the perineum and introduce a Watson drainage-tube.

Step 2.—Recognize the line of junction between the mucosa of the gutter-like uretrha and the skin of the penis. On each side of the urethral groove make a longitudinal incision along the lines of muco-cutaneous junction, from the symphysis to the extremity of the glans. (Fig. 882, *a*.) Unite the incisions above the opening into the bladder. The incisions penetrate to, but must not injure the corpora cavernosa. Separate the urethra, as a flap, from its bed and hold it aside. (Fig. 882, *b*.)

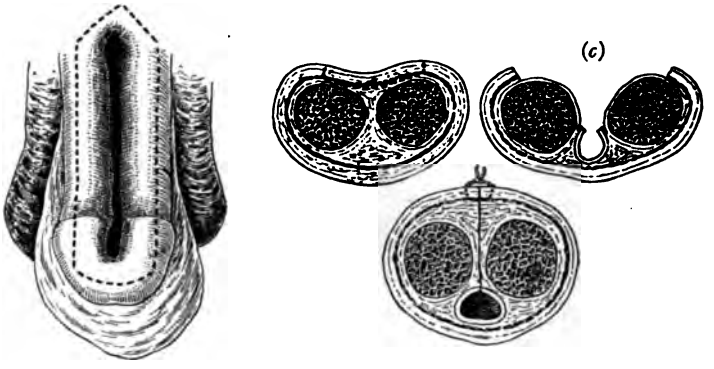

FIG. 882.—Cantwell's operation.

Step 3.—With sharp and blunt dissection separate the one corpus cavernosum from the other until the skin on the lower surface of the penis is reached. (Fig. 882, *c*.)

Step 4.—Place the mobilized urethra in the bottom of the long penile wound and fix it there by a couple of sutures.

Step 5.—Lay a sound or a glass rod along the urethra (which is a mere groove) and suture the urethra over the rod so as to form a tube. Remove the rod.

Step 6.—Bring the corpora cavernosa together over the urethra and close the wound. (Fig. 882, *d*.) The urethra now occupies its normal site.

Harold Stiles' Operation.—("Epispadias in the female" "Trans. Am. Surg., Assoc.," 1911.)

1. **Trendelenburg's Position.**—Subumbilical right rectus incision.

2. Divide the peritoneum covering the ureter where it crosses the termination of the internal iliac artery to go "downwards and forwards towards the base of the broad ligament, a little below the infundibulopelvic ligament and the ovarian vessels." Be careful to avoid injury to the ureteric vessels. By blunt dissection free the ureter with its vessels, up to the pelvic brim and down to the base of the broad ligament. Ligate the ureter with catgut close to the

bladder; apply a fine clamp to the ureter a little above the ligature; divide the ureter between the clamp and ligature; cauterize the distal stump. Prepare a fine catgut suture by threading each end on a fine needle. Pass the needles from within outwards through the whole thickness of the ureteric wall and distant from each other about one-third the circumference of the ureter. Wrap the mobilized ureter and the catgut suture with needles still attached, in a pad of gauze.

3. Pull the lowest part of the pelvic colon into the wound and apply longitudinally to it a fine intestinal clamp in such a manner as to segregate the antimesenteric edge of it for about 3 inches (Fig. 883). Make a very small cut transversely through the gut wall down to but not through the mucosa at the junction of the middle and lower thirds of the clamped-off portion. Make

FIG. 883.—(*Stiles.*)

a small opening through the mucosa. Pass the two needles of the ureteric suture through the mucosal wound and make them penetrate the wall of the gut from within outwards. Push the end of the ureter into the gut. Tighten and tie the catgut suture. With silk or hemp, suture two parallel folds of gut wall over the implanted ureter and the original catgut stitch in the Witzel method (see Gastrostomy). The stitches should pick up a sero-muscular fold on the side of the ureter but must not enter its lumen. Remove the intestinal clamp.

4. Suture the divided peritoneum on the floor and posterior wall of the pelvis with catgut, leaving a small opening at the uppermost part for the passage of the ureter. It is important to make sure that the portion of ureter "which passes from the opening left in the peritoneum to the site of implantation should be as short as possible, and it is with this object in view that the implantation in the pelvic colon is made as near the rectum as possible." This to avoid risks of internal hernia.

5. Close the abdomen without drainage. Stiles operates on the other ureter from three to six weeks later.

CHAPTER LIII

HYPOSPADIAS

In hypospadias, owing to an error in development, the urethral floor is defective. The defect may be slight or great, and according to its degree the deformity is of the following types: (1) Balanic, *i.e.*, confined to the glans, the urethral meatus being immediately behind, while the balanic urethra is absent or represented by a mere groove or gutter. (2) Penile type. The urethral opening is situated at any point between the scrotum and the glans; the anterior urethra is absent or represented by a mere groove. (3) Perineoscrotal type. The urethral opening is in the perineum and the scrotum is divided.

In any form of hypospadias except the mildest the defective penis is curved downwards, and held in a position of chordee by dense fibrous tissue bands which exist on its lower surface. These bands are an important element in treatment, as no operation can be of any value which does not correct the curvature. Duplay corrects the chordee deformity by making transverse incisions through the fibrous bands. The incisions may be subcutaneous or open, according as the skin is contracted or loose. When the incisions are open, they may be covered by skin-grafts or rendered longitudinal by means of sutures. Bleeding is not great, as any tissues divided are sclerosed. Some surgeons excise much of the scar tissue. The straightening of the penis must be thorough, if requisite several incisions being employed. While healing is progressing the corrected position may be retained by strapping the penis to the belly-wall. (In cases of epispadias a splint is requisite.) Several weeks may be spent in obtaining a straight organ.

Where the deformity is of the balanic type, the foreskin may be complete or may be divided; in the latter case it is usually redundant and hangs over the glans as a hood. Operation is required because of narrowness of the urethral opening and because of the great inconvenience arising from the impossibility of directing the stream in urinating. If the urethra is represented by a groove on the under aspect of the glans, it may be converted into a tube by freshening its edges and uniting them over a glass rod, or by an operation identical with that of Thiersch. (See "Epispadias.")

In a case in which the above operation had been unsuccessful the author obtained a good result from utilizing the foreskin in the following way: Vivify one edge of the urethral groove (X Y, Fig. 884). Divide the foreskin along the line X Y. Suture the raw edge of the foreskin wound Y P, to the freshened edge of the urethral groove X Y (Fig. 885). Wait until union has taken place. Divide the foreskin along the line A B, Fig. 885. Freshen the corresponding edge of the urethral groove. Unite with sutures the raw edge of the foreskin to the edge of the urethral groove. The result is shown in Fig. 886.

Beck's Operation.—Beck's operation is suitable, not only in cases where the urethra is defective at the glans, but where it is defective for a short distance behind it.

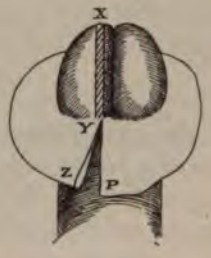

FIG. 884.

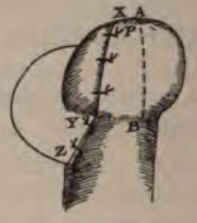

FIG. 885.

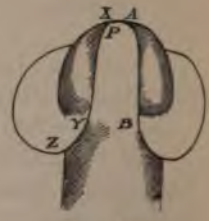

FIG. 886.

Dissect the distal end of the complete urethra free from its surroundings for a suitable distance (Figs. 887, 888, 889, 890). This mobilizes the tube so that it can be pulled forwards and sutured to the vivified urethral groove on the under surface of the glans. Where there is no urethral groove on

FIG. 887.

FIG. 888.

FIGS. 887 AND 888.—(*Beck.*)

the glans, some surgeons perforate the glans from before backwards or from above downwards and backwards (Ochsner) and pull the mobilized end of the urethra through the tunnel, suturing it there. When the defect belongs to the penile or scroto-perineal type, other operations are required.

Duplay's Operation.—First sitting: Straightening of the penis.

Second sitting: Correction of the deformity in the glans, as in Thiersch's operation for epispadias.

Third sitting: Establish perineal drainage, by the boutonnière operation. C. H. Mayo advises the introduction of a Pezzer's self-retaining female catheter through the perineal wound. Correct the urethral deformity as follows: Make a longitudinal incision (A, B, Fig. 891) parallel to and about ¾ inch distant from the edge of the urethral groove. At each end of this incision make a transverse incision beginning at the edge of the urethral groove and ending at a point well external to the longitudinal cut. These cuts outline two flaps, one of which

FIG. 889.

FIG. 890.

FIGS. 889 AND 890.—(*Beck.*)

(X, Fig. 891) has its base at the urethral groove; the other, P, has its base towards the side of the penis. Reflect these flaps. On the opposite side of the urethral groove duplicate the above incisions and form the flaps Y and Q. Pass a rod through the lately formed urethra of the glans and permit it to lie in the urethral groove. Reflect the flaps X, Y, on to the rod (Fig. 892) so that their epidermal surfaces next to the rod and their raw surfaces are exposed. These two flaps should *not* be so wide that their edges meet over the rod. Approximate the flaps P and Q by means of the suture s s^1 (Fig. 892). The skin is so loosely attached to the penis that it is easy to slide the flaps P and Q inwards so that their raw surfaces are partly in contact with those of [illegible] and partly with one another. The sutures, of silkworm-gut or silver wi[illegible]e fastened to perforated lead plates which extend the whole length [illegible]nd on each side of it (quill

sutures). The lead plates prevent the sutures cutting out and assist in keeping the parts at rest.

The above operation is a modification of Duplay's operation for epispadias. After the penile urethra is completely formed there is still a hiatus between it and the urethra leading from the bladder. This hiatus is closed in the manner described in the chapter on "Epispadias."

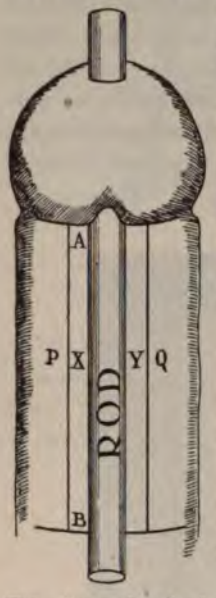

FIG. 891.—Duplay's operation.

Thiersch's operation for epispadias is also suitable in hypospadias.

Many ingenious operations have been devised by which a new urethra is formed from the skin of the scrotum (Rosenberger, Wood, etc.). All these are objectionable in that hair will grow on the skin used in the making of the new urethra and cause an infinity of trouble.

Nové-Josserand has devised a most ingenious method of operating, but whether it will prove of much value or not is still doubtful. The operation is performed as follows: Divide the skin transversely immediately in front of the urethral opening (A, Fig. 893). From this cut make a subcutaneous tunnel, by means of a trocar, to the point of the penis. Cut a large Thiersch skin-graft and roll it around a glass rod, fixing it to the rod by means of a ligature at each end (Fig. 894). Pass the rod covered with the graft through the newly made tunnel in the penis. Apply dressings. After eight days remove the rod. It will be wise to drain the bladder by means of a Pezzer's self-retaining catheter introduced through a perineal incision, and thus avoid contamination of the wound with urine. For a few months after recovery pass sounds at intervals, as there is a tendency to contraction. Various materials have been used to take the place of skin in the Nové-Josserand operation. Schmieden has implanted a ureter obtained during an operation for hydronephrosis; experimentally an artery has been utilized. Tanton published in 1909 an experiment in which he replaced the urethra by implanting a segment of vein. Tanton, Tuffier, Stettiner, have applied this experiment to man and have been successful ("Journal de Chir.," June, 1910).

FIG. 892.—Duplay's operation.

The operation for the posterior penile type of hypospadias is performed in two stages at an interval of from two to five weeks.

First Stage.—(*a*) Correct the chordee as already described.

(*b*) Provide for suprapubic drainage through as small an incision as possible and without suturing the bladder to the skin. Keep the bladder clean by frequent irrigations with a mild antiseptic solution. Change the drainage tube at intervals as it becomes encrusted with urinary salts.

Second Stage.—(*a*) Excise a segment of the internal saphenous vein. The segment ought to be about 50 per cent. longer than the portion of urethra to

e constructed, as the excised vein shrinks greatly. Wash the vein and preerve it in warm salt solution.

(*b*) Introduce a sound into the hypospadiac opening and mobilize the urethra around the sound by careful dissection.

(*c*) Make a tunnel as in the Nové-Josserand operation from the glans through the penis to the incision around the mobilized urethral opening.

(*d*) With vaseline lubricate a bougie and pass it through the segment of vein obtained in step *a*.

(*e*) Pass the bougie, with the vein on it, through the tunnel made in the penis and make the point of the bougie go into the mobilized urethral orifice.

FIG. 893.

FIG. 894.

FIGS. 893 AND 894.—Nové-Josserand's operation. (*Monod and Vanverts.*)

(*f*) Suture the open end of the vein to the open end of the mobilized urethral orifice by means of mattress sutures which cause eversion. (To the author this seems bad practice, as it must bring the inner surface of the vein into apposition with the inner or *epithelial* surface of the urethra, a condition which must be inimical to healing.)

(*g*) Having anastomosed the implanted vein to the urethral orifice, close the wound on the under surface of the penis (or perineum) with one or two rows of sutures. Place a very small drain under the skin for twenty-four or forty-eight hours.

(*h*) Unite the other end of the vein to the edges of the wound in the glans. Remove the bougie.

After-treatment.—Remove the drain after twenty-four to forty-eight hours. After the lapse of five or six days inject, *most gently*, enough sterile olive oil to slightly distend the new urethra. Repeat the injection daily. After about

two weeks begin the use of sounds, but use them gently and at intervals of two or three days. Only after the lapse of about one month is it proper to pass sounds large enough to really dilate the new urethra. When the new urethra has become thoroughly acclimatized introduce a catheter and leave it in place until the hypogastric fistula has closed.

Tanton's operation promises well, but late results have not yet been reported.

FIG. 895.

FIG. 896.

FIGS. 895 AND 896.—(*C. H. Mayo.*)

Van Hook ("Annals of Surgery," April, 1896) and C. H. Mayo ("Journ Am. Med. Assoc.," April, 1901) have devised very similar operations which may be performed as follows:

"The prepuce is extended as for circumcision and two incisions are made, about 1 inch apart, extending from its border to its attachment at the penile cervix; the prepuce is unfolded, forming a loop of thin skin about 2½ inches in length. Should this not be considered sufficient to reach from its attachment to the hypospadiac opening, the two incisions are extended back along the dorsum of the penis until sufficient tissue is obtained, where the two incisions are connected by a transverse one, and the flap of skin lifted but left attached to the cervix by the inner surface. Several sutures now close the lateral integument over the denuded area (Fig. 895). The pedunculated flap of prepuce is constructed into a tube with its skin or outer surface inside, by means of a number of catgut sutures. The penis is tunneled by means of a narrow bistoury or medium trocar and cannula, through the glans, above its groove, along the penis to a point beneath the hypospadiac opening, when it is made to emerge at one side of, but close to, the urethra; the tube of prepuce is drawn through the tunnel and sutured where it enters the glans and also where it emerges (Fig. 896). At the end of ten days the pedicle of the flap is cut through close to the new meatus. The second operation, made at a later period, consists of a perineal opening into the urethra and insertion of

FIG. 897.—(*C. H. Mayo.*)

a Pezzer's self-retaining female catheter; this is the least irritating form of catheter and can be left as long as needed—usually from five to eight days. An incision at the termination of the two urethras now admits of accurate coaptation by sutures, or the normal urethra may be mobilized (Beck method) to a sufficient extent to admit of its insertion into the new urethra, where it is held by sutures and the external parts closed over this (Fig. 897). Occasionally a little urine escapes into the urethra, and the entire canal is best drained by passing several strands of silkworm-gut or horse-hair through the urethra and out alongside the catheter in the perineal opening."

CHAPTER LIV

AMPUTATION OF PENIS

Partial Amputation.—I. *Amputation of Glans and Part of Penis.—Step* 1.—Apply an elastic constrictor to the root of the penis. Make an incision through the skin completely round the penis and at least ¾ inch distant from the disease. Retract or reflect the skin upwards for about ½ inch. (The natural elasticity of the skin will produce enough retraction without the aid of the surgeon.)

Step 2.—Expose and ligate the dorsal artery and veins of the penis.

Step 3.—Divide the corpora cavernosa transversely. At a point nearly ½ inch farther forward divide the urethra transversely.

Step 4.—With catgut suture the ends of the corpora cavernosa (Fig. 898). This assures hæmostasis.

Step 5.—In the middle line below make a short incision through the skin. Make a corresponding cut in the urethra (Figs. 898 and 899). Suture the split urethra to the skin. This splitting and suturing prevents contraction.

FIG. 898.

FIG. 899.

FIGS 898 AND 899.—Amputation of penis.

Nicoll, most sensibly, modifies the operation as follows: Step (*a*): Make an incision over each inguinal region. Unite these incisions in the middle line at the root of the penis and from their point of union make an incision along the mid-dorsal line of the penis to the place chosen for amputation. Step (*b*): Beginning at each groin dissect free, from the outside inwards, the lymphatics of the groins and then, from above downwards, those of the dorsum of the penis. Remove all these lymphatics in one piece. After this proceed to amputate.

II. *Complete Amputation.* (Gould's method.)—Place in lithotomy position.

Step 1.—Split the scrotum completely along raphé, and thoroughly expose the corpus spongiosum.

Step 2.—Pass a sound through the urethra to the triangular ligament. Separate the corpus spongiosum from the corpora cavernosa. Remove the

sound. Divide the corpus spongiosum and isolate the urethra as far as the triangular ligament.

Step 3.—Continue the scrotal incision through the skin around the root of the penis. Divide the suspensory ligament. Separate the crura from the pubic bones. The only vessels requiring ligation are those of the crura. This completes the amputation.

Step 4.—Make a short split in the urethral stump. Suture the edges of the split urethra to the posterior portion of the scrotal wound.

Step 5.—Suture the skin wound after providing for drainage.

Remarks.—Very good results have been obtained by the above operations with or without removal of the inguinal lymph glands. Cancer of the penis is usually of comparatively slow growth. Recurrence usually is in the lymph glands. Butlin advises removal of the inguinal glands as a secondary operation. If the urethra is split and united to the skin as described, difficulties in micturition are largely avoided. Amputation at the junction of the middle and distal third or at the middle of the penis does not necessarily destroy the power of coitus and begetting (Butlin). The danger of the operations described is not much over 2 per cent.

III. *Emasculation.*—If the disease is extensive or of rapid growth a much more serious and radical operation is proper. This operation is based on a study of the penile lymphatics.

The lymphatics of the penile skin and of the prepuce anastomose freely and drain into the superficial lymphatic glands on *both* sides. The lymphatics of the glans pass up along with the dorsal veins of the penis to a few lymphatic glands which lie in front of the pubis; from this point they take two courses: (*a*) to deeply located glands lying on the inner side of the femoral vein, (*b*) along the inguinal canal under the spermatic cord.

From the above (see "Traité d'Anatomie Humaine," Poirier et Charpy, Tome II) it is evident that it is safe to make a difference in the extent of operation according as the glans is involved or not. If the glans is not affected a theoretically complete operation means removal of the superficial lymph glands from both inguinal regions, removal of the penis and removal of the lymph channels between the penis and the lymph glands. If the glans is also involved a theoretically complete operation means removal of the above structures *plus* the deep inguinal glands to the inner side of the femoral vein and *plus* the lymphatics under the cord in the inguinal canal and *plus* the prepubic glands. Technically it may be possible to do all this and preserve the scrotum and testicles, practically it seems better to remove these organs also. In the operation to be described it is assumed that the glans is affected. The method is one which the writer elaborated for his own use, but which is, of course, not original.

FIG. 900.—Exposure and ligation of cord high up.

Step 1.—After the usual cleansing and shaving of the whole operative territory, clean the diseased parts as well as possible, swabbing them with Harrington's solution or liquid carbolic or even touching them with the cautery.

Apply dressings to the disease and cover them with oiled silk. Suture the dressings or coverings to the skin of the penis. These precautions are taken to prevent infection. Once more clean the operative territory.

Step 2.—Make an incision over the inguinal canal parallel to Poupart's ligament. Open the canal by splitting the aponeurosis of the external oblique. Lift up and mobilize the spermatic cord and all the fat surrounding it. Doubly ligate and divide these structures as high up as possible (Fig. 900). Obliterate the now empty inguinal canal by suturing the wound in the aponeurosis (Fig. 901).

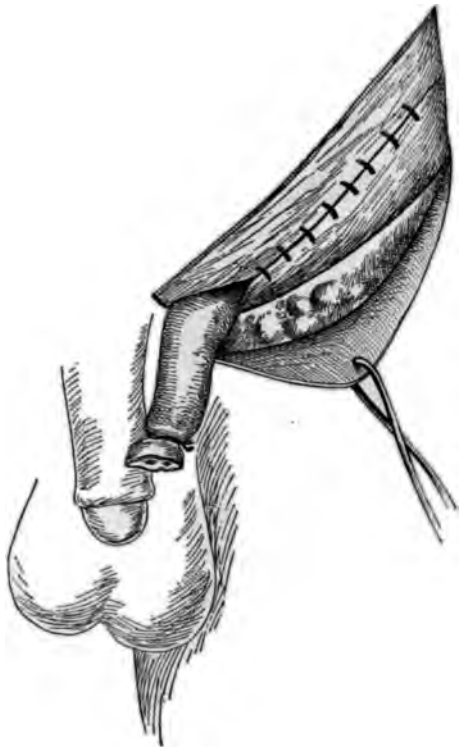

FIG. 901.—Closure of inguinal canal.

Step 3.—Through the original wound, supplemented if necessary by a subsidiary incision, expose Scarpa's triangle above the saphenous opening (Fig. 901). Beginning at the lower and outer sides of the exposed area, dissect the superficial inguinal glands, along with the fat surrounding them, upwards and inwards towards the pubis.

Step 4.—Expose and remove the deep inguinal glands. These vary in number from 1 to 3. When three are present one lies just below the long saphenous vein, one in the femoral canal, and one in the femoral ring. All are to the inner side of the femoral vein.

Step 5.—Repeat steps 2, 3, 4 on the opposite side. Incise the skin immediately above the root of the penis, uniting by this cut the two incisions over the inguinal canals. On each side of the root of the penis make an incision

downwards over the root of the scrotum. Dissect downwards the fat in
of the pubis, until the crura of the penis are exposed. Divide the suspen
ligament. The results of the work accomplished up to this point are:
All the lymphatic glands and tissue which may presumably be affected

FIG. 902.—Operation of emasculation.

dissected free and now hang, along with the spermatic cords and the prepu
fat, attached to the penis and scrotum (Fig. 902). The inguinal canals wh
were opened have been closed. Any wound which may have been made
expose Scarpa's triangle may now be closed.

FIG. 903.
I, I. Inguinal wounds. *SF.* Scrotal flap. *U.* Urethral opening.

Step 6.—Working from above downwards, separate the crura of the p
from the pubic bones. Complete the incision through the scrotum b
and behind. Expose and mobilize the corpus spongiosum at the root of
scrotum. Divide the corpus spongiosum and urethra. A few catgut sut

hrough the cavernous tissue prevent hemorrhage. It is now easy to remove, *n one piece*, the penis, scrotum with its contents, superficial inguinal glands, nd the lymphatics of the inguinal canal. (The deep inguinal glands were emoved separately.)

Step 7.—Make a slight split in the urethral stump and suture the edges f the urethral wound to the most posterior part of the cutaneous wound. lose the extensive skin wound with sutures after providing, where necessary, or drainage.

N.B.—When removing the scrotum it is well to leave enough of its posterior wall to be brought forward and upward and united to the edge of the ound across the pubis. When this is done the urethra can be brought through button-hole cut in the base of the scrotal flap (Fig. 903). When removing he scrotum v. Dittel retained a portion of the posterior scrotal skin which e wrapped around the stump of the corpus spongiosum (left long for this purose). The effect of this detail was the formation of a sort of "spout" which nabled the patient to urinate without taking down his trousers.

CHAPTER LV

CIRCUMCISION

There are several methods of performing circumcision; most of these are erely modifications of the following:

Classical Method.—Feel and locate the corona or groove behind the glans enis; the prepuce being in normal position is not retracted. Place a clamp

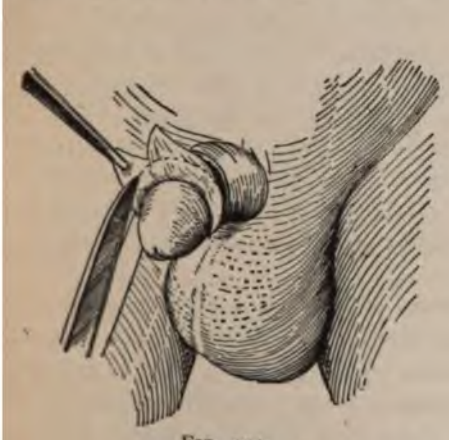

FIG. 904.

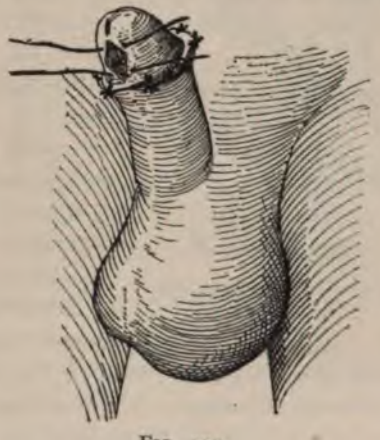

FIG. 905.

FIGS. 904 AND 905.—Circumcision. (*Veau.*)

he handles of a long scissors form an efficient clamp) on the skin correspondg to the corona. Gently tighten the clamp so as to hold the skin between s blades and yet permit the glans to be pushed back behind it. Push back e glans so that it lies in safety behind the clamp. Tighten the grasp of e clamp. The whole skin and part of the mucous membrane of the prepuce

now lie in front of the clamp; the glans and part of the mucous membrane of the foreskin lie behind it.

Remove, with a knife, all the structures in front of the clamp. Remove the clamp. The skin retracts to the root of the penis; the glans is covered by a tube of mucous membrane having a raw and bleeding external surface. Cut away (Fig. 904) all except about ⅓ inch of the mucous membrane. If the frenum is short and pulls the glans downwards and backwards, divide that structure *transversely* and in suturing convert the transverse into a longitudinal wound, thus lengthening the frenum (Fig. 905). Pull the skin forwards and suture it to the mucous membrane. Apply vaseline or some ointment to the wound and protect with a small piece of gauze. No elaborate dressings are of any value. Warn the patient or his mother that the penis will become swollen and discolored; this warning may prevent the operator being summoned to treat non-existent hemorrhage. Serious post-operative hemorrhage is rare. Before operating, especially if cocaine is used, it is well to apply an elastic constrictor round the root of the penis.

A Typical Operation.—With scissors or knife split the prepuce in the mid-dorsal line to the corona. Beginning at the angle of the wound trim away as much of the redundant tissues as may seem necessary. Stitch the skin to the mucous membrane.

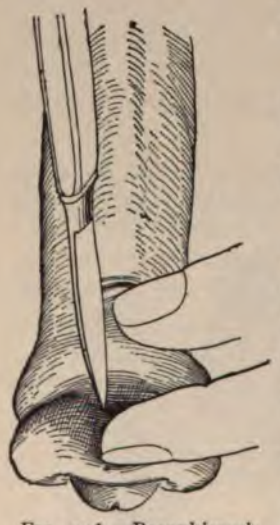

FIG. 906.—Paraphimosis. (*Veau.*)

Many surgeons omit the removal of any tissue after splitting, but this, at least temporarily, leaves the foreskin hanging below the glans like an elephant's ear and causes much annoyance to the sensitively inclined.

The adhesions which so commonly exist between the prepuce and the glans are as a rule easily separated, but occasionally they are so firm as to require sharp dissection. In such a case the author, after dissecting the prepuce from the glans, folded the redundant prepuce on itself so that a short prepuce was formed lined with epidermis and so reformation of adhesions was prevented. Possibly it would have been well to have covered the raw surface of the glans with skin grafts.

Paraphimosis.—The foreskin is retracted, swollen, and cannot be brought forwards. The constricting band obstructing reduction is the margin of the preputial orifice (the muco-cutaneous junction). The retracted foreskin forms two swellings surrounding the penis; the constricting band lies in the groove between the swellings.

A. By manipulations endeavor to push back the glans and bring forwards the prepuce. If successful, advise or perform circumcision to prevent recurrence.

B. If manipulation fails, operate. With the fingers separate the anterior from the posterior penile swellings and so expose the constricting band. Divide the band in the mid-dorsal line; reduction is now easy (Fig. 906). Advise or practise circumcision.

CHAPTER LVI

OPERATIONS ON THE TESTICLES

CASTRATION; ORCHIDECTOMY; ORCHI-EPIDIDYMECTOMY

I. Simple Castration.—*Step* 1.—Make an incision 2 or 2½ inches in length downwards from the level of the external abdominal ring. Through this isolate the spermatic cord by blunt dissection.

Step 2.—If the cord is not very thick, crush it forcibly with powerful forceps. In the groove formed by the clamp tie a ligature tightly around the whole cord. Thread one end of the ligature on a needle and pass it through a small portion of the cord distal to the main ligature. Once more tie. This stitch obviates any possibility of the ligature slipping. Some surgeons carefully avoid including the vas deferens in the ligature lest pain result. Jacobson believes that if the ligature be applied very tightly pain will not develop. Crushing the cord before applying the ligature has the same effect. When the cord is large, or if for any reason a single ligature seems objectionable, two or more interlocked ligatures may be applied. Absorbable or non-absorbable ligatures may be used at the option of the surgeon. Plain or iodized catgut serves every purpose excellently. Apply a clamp to the cord, about one inch distal to the ligature. Divide the cord between the clamp and ligature. Examine the ligated stump, which may be allowed to retract into the inguinal canal if it is healthy and is not bleeding.

Step 3.—With the hand on the scrotum make the testicle with its coverings protrude through the wound. By blunt dissection, separate it with its coverings from the scrotum, and so remove it.

Step 4.—Carefully review the wound and stop all bleeding. If drainage is required, perforate the scrotum at a dependent point, and through the perforation introduce a capillary or tubular drain.

Step 5.—Close the wound with sutures. The objects in making the skin-incision at a high rather than a low level are: (*a*) It is more easy to separate the cord and the testicle from their surroundings; (*b*) the whole vascular supply is under control from the beginning: (*c*) it is much easier to retain suitable dressings over the wound.

II. Castration for Malignant Disease.—This operation as commonly performed is a farce and recurrence is certain. The usually described method is that of simple castration, which is as ineffective as simple excision of the cancerous breast when the axillary glands are involved. When the testicle is the seat of malignant disease, the same principle holds good as in the case of the breast, viz., to remove *en masse* the whole organ plus all the *accessible* lymphatic tissue through which it is normally drained. Unfortunately, the terminal lymphatics are not accessible. The lymphatics of the testicle, epididymis, and visceral layer of the tunica vaginalis run along the spermatic cord to the lumbar region. They are usually superficial to, but in contact with, the blood-vessels. In the lumbar region they leave the spermatic vessels and

run towards their terminal glands. The terminal glands are grouped around the aorta (right and left juxta-aortic glands) (Cuneo). The lymphatics of the scrotum terminate in the inguinal glands.

Cumston and Rolfe ("American Med.," 1903, 607) have given a good description of the methods to be employed; the following is largely based on their paper.

Step 1.—Make an incision parallel to and one inch above Poupart's ligament from a point a little below the external inguinal ring to a point about one inch above the internal ring.

Step 2.—Expose the fascia of the external oblique and split it, as in Bassini's hernial operation, from the external ring to a little above the internal ring. Retract the flaps of fascia thus formed.

Step 3.—Push the internal oblique muscle aside and thus expose the inguinal canal and spermatic cord. Dissect the cord from its bed. Open the posterior wall of the inguinal canal and invade the iliac fossa.

Step 4.—The elements composing the cord become separated at the internal ring, the vas going down towards the small pelvis, the spermatic vessels and lymphatics going up towards the lumbar region, on the psoas muscle. Follow the vas deferens as far as possible towards the deep pelvis and there ligate and divide it. Cauterize its stump with pure carbolic acid or the cautery. Follow the spermatic vessels up towards the lumbar region as far as possible and there doubly ligate and divide them.

Step 5.—Beginning above at the site of division of the vas and of the spermatic vessels, separate the cord and its envelopes downwards, to a point below the external inguinal ring. By pressing on the scrotum it is easy to deliver the testicle with its envelopes through the wound and remove them together with the cord. If the scrotum is adherent to the testicle, make a liberal excision of the scrotal skin and all the structures between it and the testicle. This is done by continuing the original incision downwards and making it surround the affected area. Remember that if the scrotum is involved the inguinal lymphatic glands may be affected and should be removed, as it is into them that the scrotal lymphatics drain.

Step 6.—Review the wound with care and attend to hemostasis. Close the wound exactly as in an operation for the radical cure of hernia.

Radical Operation for Teratoma Testis.—Cuneo resected the lumbar gland bearing area in a case of teratoma testis in 1906, the patient remained well until lost sight of three years later. Gregoire and Chevassu later performed four similar operations with encouraging results. Hinman (Surg., Gyn. and Obst., May, 1919) reports five cases in which he operated successfully.

Step 1.—Dorsal position. Make an incision into the inguinal canal. Expose and free the cord high up. Divide the cord with the cautery between clamps. Excise the testicle. If immediate examination of the specimen proves it non-malignant complete the operation by attending to hemostasis and closing the canal and wound. If malignancy is present proceed to

Step 2.—Place the patient midway between the lateral and dorsal positions (diseased side uppermost) with a medium sized pad under the opposite costal margin. The position is bent dorso-lateral.

Continue the original incision upwards and outwards, splitting the external ique in the direction of its fibers to a point about 2 cm. (¾ in.) internal the anterior superior spine.

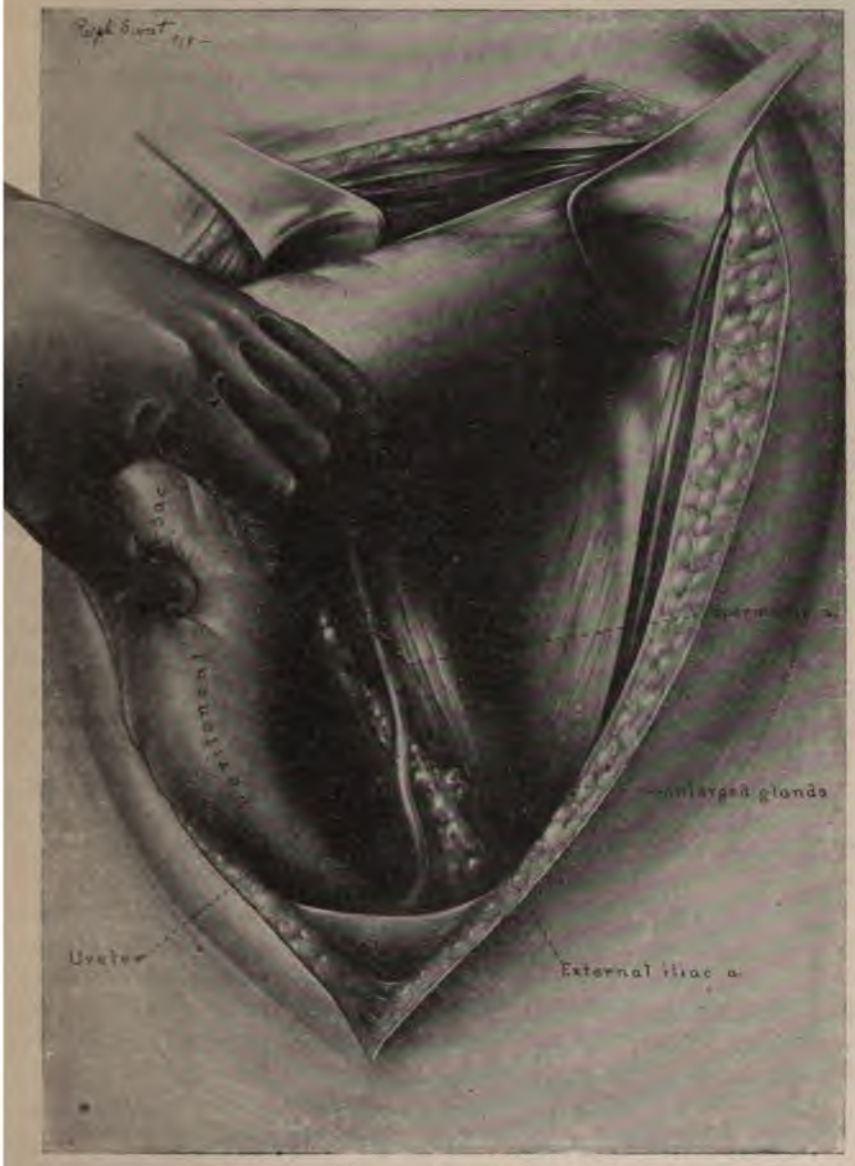

FIG. 907.—(*Hinman, Surg. Gyn. & Obst.*)

From this point continue the cut in a curved direction to about 1 cm. below tip of the twelfth rib and carry the cut parallel to the rib for about half its gth. Divide the internal oblique, transversalis and latissimus dorsi in the e of incision. In this exposure the iliac branch of the ilio-hypogastric nerve necessarily sacrificed. Expose but do not injure the peritoneum, Fig. 907.

Step 3.—Separate the parietal peritoneum from the posterior abdominal wall. The spermatic vessels as well as the ureter tend to strip up with the peritoneum. To overcome this exercise gentle traction on the cord during the stripping. At this point where the vas deferens passes down behind the bladder the peritoneal boundaries may be with difficulty outlined. This dissection should be carefully completed before proceeding with that above. Divide the vas where it disappears behind the bladder. While exerting gentle traction on the cord strip the peritoneum from the iliac vessels and the bifurcation of the aorta. In this way expose the psoas muscles with the ureter overlying them, the lower pole of the kidney, the aorta and vena cava. Continue the peritoneal dissection as high as the renal pedicle.

Step 4.—Dissect the lymphatic tissues, *first* from the iliac vessels and aortic bifurcation beginning below and working upwards and *second* from the pre-aortic area. Hinman found that 'in all instances by careful dissection, it was possible to remove the spermatic and lymph areas *in toto*. The spermatic artery can be easily clamped as it leaves the aorta, and the spermatic vein as it enters the vena or renal vein, the points being easily found when gentle traction is placed on the vessels.

FIG. 908.—Epididymectomy. (*Monod and Vanverts.*)

Step 5.—*Drainage.*—Hinman advised the use of a 'long rubber tube over the aorta down to its bifurcation and curving back above the ilium with exit at the upper back portion of the wound as for kidney drainage.' He also suggests that a 50 milligram tube of radium might be laid along side the drain and moved certain distances at intervals of one or two hours. The propriety of using a rubber tube is problematical as rubber dam would serve the same purpose and present less danger of causing pressure necrosis.

Step 6.—Close the wound in layers.

Epididymectomy.—This operation may be done alone or vasectomy may be added to it.

Step 1.—Make an incision into the tunica vaginalis, just external and parallel to the epididymis. If the epididymis is adherent to the skin or fistulæ are present, such adherent skin and fistulæ should be surrounded by elliptical incisions and removed with the epididymis.

Step 2.—Make an incision along the junction between the epididymis and testicle on the *outer side*. This incision divides the serous membrane alone opposite the body of the epididymis, while at the head and tail (globus major and minor) it divides the tunica albuginea. With knife or scissors separate the head (globus major) from the testicle. Next separate the body of the epididymis from the testicle (Fig. 908). As the *inner* side of the junction between the epididymis and testicle is reached, proceed with great care, because here the vessels going to the testicle are in contact with the epididymis.

By making slight traction and putting the structures of the cord gently on the stretch, it becomes easy to separate the epididymis from the vessels.

Step 3.—The epididymis being free, continue the dissection by separating the vas from its surroundings up to the internal ring, "where it is grasped on both sides of its circumference with hemostatic forceps, divided, and the lumen of the proximal end cauterized with 95 per cent. carbolic acid on the end of a needle. The needle is to be worked upwards in the lumen for ½ inch and the mucous membrane thoroughly cauterized." Ligate the proximal end of the vas. This is important in that it prevents infectious material being voided from the vas into the tissues.

Step 4.—Review the wound made in the testicle by the removal of the epididymis. If any foci of disease are found, excise them by wedge-shaped incisions and close the wounds with fine catgut. Suture with catgut any wound in the tunica albuginea. If the condition of testicle makes one suspect disease in it, it is proper to make an exploratory incision into it. Such incision must be closed with catgut sutures should no further procedure be indicated.

Step 5.—Having attended to hemostasis, close the external wound with sutures. It is well to provide drainage for twenty-four or forty-eight hours.

In some cases it is possible to remove disease from the epididymis by partial or complete excision of that organ, without removing so much of the vas as was recommended in the preceding paragraphs. When this is possible, one may follow the suggestion of Bardenheuer, which was first carried out by Rasumowsky ("Archiv f. klin. Chir.," lxv, p. 557), viz., to make an anastomosis between the vas and the *rete testis* or the remnants of the epididymis.

Suture of the Vas Deferens after Division.—Accurate end-to-end anastomosis may be difficult because of the small lumen of the vas. W. I. deC. Wheeler (Brit. Med. Journ., Feb. 7, 1914) recommends the following method: Pass the point of a fine sewing needle into the lumen of one of the segments of vas and slip the other segment of vas over the eye end of the needle until the two segments meet. Suture. After suturing make the needle, which is inside the vas, penetrate its wall. Extract the needle. Cover and reinforce the line of suture with neighboring fascia.

Anastomosis between the Vas Deferens and the Rete Testis.—*Step* 1.—Completely excise the epididymis, removing as little of the vas deferens as possible.

Step 2.—Pass a fine probe or director into the vas and with this as a guide split the vas for a little less than half an inch.

Step 3.—With fine catgut sutures, introduced in the Lembert fashion, unite the gaping end of the vas to that part of the testicle from which the head of the epididymis was removed (rete testis, beginning of the coni vasculosi).

Step 4.—Partially bury in the testicle the site of anastomosis, by means of a few heavy sutures introduced in the Lembert fashion (Fig. 909).

Step 5.—Cover the line of sutures in the testicle by closing with catgut the wound in the tunica vaginalis etc. Close the skin-wound.

Anastomosis between the Vas Deferens and the Epididymis after Partial Excision of the Latter.—*Step* 1.—Excise the tail and part of the body of the epididymis, dividing the body transversely.

Step 2.—Split the vas for about ½ inch, and introduce into it (in the Lembert fashion) two fine catgut sutures.

Step 3.—Perforate or tunnel the remaining portion of the epididymis (head and part of body) with a pointed knife introduced through its cut surface. Through this tunnel pass by means of needles the catgut sutures attached to the vas (Fig. 910).

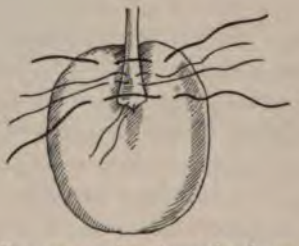

FIG. 909.—Anastomosis of vas to testis.

FIG. 910.—Anastomosis of vas to epididymis.

Step 4.—By pulling on the catgut threads insinuate the open end of the vas into the tunnel and fix it there by tying the catgut sutures. One or two extra sutures may be used to complete the union.

Step 5.—Close the wound in the overlying tissues by one or more layers of catgut sutures.

Excision of the Vas Deferens with or without the Seminal Vesicle; Vasectomy.—The term "vasectomy" is properly applied to this operation, but custom seems to have limited its use to the mere division or removal of a small segment of the vas in cases of prostatic hypertrophy. Vasectomy, in the latter limited sense, is peformed by incising the skin immediately below the external abdominal ring, exposing the cord, separating the vas from the other structures of the cord, and dividing it between two ligatures. J. W. White and R. Harrison have found much benefit result from this simple operation. Vasectomy, in the wider and proper sense of the term, is a much more serious procedure—so difficult, indeed, that a number of operators have discarded its use. Vasectomy may be *partial* or *complete*.

Partial Vasectomy.—The scrotum has been opened and the testicle or the epididymis has been excised. The divided end of the vas (if not still attached to the testis or epididymis) is seized in forceps to prevent its retraction. Continue the skin-incision upwards and outwards. Open the inguinal canal by incising the aponeurosis of the external oblique. Separate the vas from the cord up to or within the internal abdominal ring. Doubly ligate the vas at as high a point as possible and divide it, being careful to cauterize the stump. Attend to hemostasis and close the wound. In many cases this partial operation suffices.

Von Büngner, instead of excising the vas as above, merely follows it to the external abdominal ring and endeavors to remove the rest of it by avulsion, in the same manner as Thiersch extracts nerves. This method might be

practicable if the vas to be removed was sound, but it is diseased and gives way at its weakest point, which is a diseased point. Theoretically, the method is bad.

Complete Vasectomy with or without Excision of the Seminal Vesicle.—Baudet and Duval have systematized this operation very thoroughly. Place the patient in Trendelenburg's position. Excise the testis or epididymis.

Step 1.—Continue the scrotal wound up to the external abdominal ring and along the inguinal canal to a point two fingerbreadths internal to the anterior superior iliac spine.

Step 2.—Open the inguinal canal by incising the aponeurosis of the external oblique. Divide the internal oblique and transversalis along the line of the skin-incision. Divide the transversalis fascia *without injuring the peritoneum.*

Step 3.—With the finger strip the peritoneum off the iliac fossa. Do *not* strip off any of the fascia with the peritoneum. It is important to keep between these two structures.

Step 4.—Incise the sheath of the spermatic cord and look for the vas beside the pubic spine. With blunt dissection follow and isolate the vas first towards the iliac fossa and then on the peritoneum, which is retracted inwards by a wide retractor. Do *not* exert any traction on the vas. Use the eye rather than the finger as a guide. During this dissection retract the epigastric artery forwards, the umbilical downwards and outwards. As the wound becomes deeper carry out the dissection with forceps. When a point deep down in the pelvis is reached, note a "tent-like" ridge passing transversely inwards from the pelvic wall. This is composed of the vesicular vessels covered by aponeurosis, and here the vas deferens enters the vesicular space. If the operation is to consist of complete vasectomy alone, doubly ligate the vas, divide and remove it. If it is desired to remove the seminal vesicle, proceed to Step 5.

Step 5.—Make a transverse tear in the fascia covering the vesicular vessels. Retract the edges of the fascial wound. Doubly ligate and divide the vessels. Beneath the vessels lies the pale, rather sinuous seminal vesicle.

Step 6.—Seize the base of the vesicle with a clamp and isolate it from its sheath, being careful, during the dissection, to keep in close contact with the vesicle so as to avoid hemorrhage. The deep portion of the vas is easily separated from the peritoneum and bladder; it lies along the inner side of and is closely attached to the vesicle.

Step 7.—With scissors separate the vas and seminal vesicle from the prostate. Cauterize the stump.

Step 8.—The most of the huge wound promptly closes itself as soon as the retractors are removed. It is well to place a cigarette drain into the depth of the wound. Close the wound in the parietes in the same fashion as in the radical cure of hernia.

Young's Operation.—("Annals of Surgery," Oct., 1900, and Nov., 1901.) "Suprapubic retrocystic extraperitoneal resection of the seminal vesicles and vasa deferentia." In several cases Young has successfully performed this most difficult operation, and has at the same time excised portions of the urinary bladder.

Make a vertical median incision from the pubis to a point above the umbilicus. At the upper end of this make a transverse incision dividing both recti muscles. These incisions penetrate to but do not involve the peritoneum. Retract the edges of the wound. Beginning below, dissect the peritoneum from the anterior bladder-wall up to and including the vertex of the bladder. At the vertex the separation is difficult. Continue the separation down the posterior bladder-wall until the seminal vesicles and vasa deferentia are exposed. Remove these, and with them any diseased portions of the prostate and bladder. (Young has removed about one-half of the bladder.) Close the bladder wound by sutures. Provide for drainage. Close the abdominal wound.

Several methods have been devised for the exposure and removal of the seminal vesicles through the peritoneum. These are so similar to some of the methods described for the exposure of the prostate that they need not be dilated upon. Schede has used the sacral and parasacral routes to reach the seminal vesicles, but other routes seem as efficient and much less formidable.

Remarks on Castration, Epididymectomy, Vasectomy, and Vesiculectomy.—In cases of malignant disease of the testicle or epididymis it is necessary to abide by the rule, do too much rather than too little. The freest possible excision of all tissue which may possibly be infected is compulsory, whether that tissue shows any signs or not. Only by conscientiously working along the lines of thoroughness can improved results be obtained. When the disease necessitating operation is tuberculosis, no such "hard-and-fast" rules meet with universal approval. König more than any other surgeon has advanced our knowledge of the surgery of tuberculosis, and hence his opinion ought to carry great weight. This surgeon and with him Kocher, Terrilon, Senn, etc., declares in favor of castration (orchidectomy) in cases of tuberculosis suitable for operation. When epididymectomy is performed, it is feared that tuberculous foci may be left in the testicle and cause further trouble, and it is assumed that no useful function can be performed by the imperfect organ left behind. J. B. Murphy, Tillaux, and others draw attention to the fact that the testicle has a useful influence on the general metabolism which must not be disregarded. The glandular portion of the testicle is practically never primarily and rarely secondarily affected to a serious extent. The results of Bardenheuer and Murphy show that epididymectomy is as curative as is castration. In suitable cases it may be well to attempt anastomosing the vas to the testicle. Bogoljuboff's experiments ("Archiv f. klin. Chir.," lxxii, p. 449) show that this operation does actually provide direct communication between the tubules of the testicles and the vas. The status of the operation is, however, by no means fixed as yet.

J. B. Murphy considers epididymectomy contraindicated (1) where there are extensive tuberculous lesions elsewhere which will shortly terminate the patient's life. (2) Where the disease has extended to and destroyed the greater part or all of the testis proper. Here castration should be done. (3) Where the scrotum is riddled with discharging sinuses. The indication is usually here also for castration. Apart from these three conditions, in every case a re-

section, typical or atypical, should be done. Murphy also points out that after epididymectomy (without anastomosis) "sexual desire and potency, even to emissions, are retained; power of procreation, however, is lost."

Horwitz comes to conclusions which are very similar to and support those of Murphy.

In a large number of cases in which there has been evidence of involvement of the vas, seminal vesicle, and even bladder, simple epididymectomy, with or without any extensive vasectomy, has given excellent results. In these cases it appears as if nature was able successfully to combat the secondary lesions when the primary one was eliminated. The profound influence exerted on the prostate, etc., by castration or epididymectomy probably effectually aids nature in her combat.

When the gravity of operations for complete vasectomy and vesiculectomy is considered, and the frequency with which all evidences of disease disappear from the neck of the bladder after simple epididymectomy and partial vasectomy, it appears wise to be conservative. Young's advice is excellent, viz., to abstain from operations on the seminal vesicles and prostate until such time as it is demonstrated that removal of the testicular foci has failed to arrest the progress of the disease in these organs and it has spread to the bladder. According to Young serious involvement of distant parts, pulmonary, urinary, osseous, etc., does not contraindicate operation. Removal of the local lesions often has a very satisfactory effect on the distant foci.

Epididymotomy.—C. P. Knight ("Journ. A. M. A.," Jan. 31, 1914) warmly recommends epididymotomy in the treatment of acute epididymitis as it is without danger, relieves pain promptly and saves much time.

Local anæsthesia. Make an incision about 1½ inches below the lower border of the external ring and prolong it sufficiently to permit free delivery of the testicle and the tunica vaginalis. Wrap the testicle in gauze moistened with warm salt solution. Make a small incision in the tunica vaginalis. Expose the epididymis and puncture, 10 or 12 times, that part of it which appears inflamed. Use a large blunt needle for making the punctures. Wash with sterile water. Reduce the testicle. Suture the cut in the tunica vaginalis, Close the skin wound. Dress. The anæsthetic agent (1 per cent. novocaine) is injected into the skin, the tunica vaginalis and the epididymis.

A. B. James (Jour. A. M. A., May 24, 1919) makes the incision one-half inch external to the raphe and large enough to permit the delivery of the testicle with its membranes intact, any hydrocele fluid present being of course evacuated. He then incises the tunica vaginalis covering the epididymis and peels it from the tunica albuginia for about one-half inch in all directions. The length of incision in the tunica vaginalis is about 1½ inches and is in the long axis of the epididymis. The tunica albuginia is similarly incised and peeled from the epididymis to a considerable extent. A blunt probe is inserted into the epididymis in various places and if pus pockets are found the probe track is dilated with forceps. A fenestrated rubber tube is laid along the epididymis and the membranes sutured over it with catgut. The skin is closed except where the tube emerges. The tube may usually be removed in two days, [redacted]ly three.

VASOSTOMY

Belfield (Journ. A. M. A., Jan. 17, 1920) remarks that epididymectomy leaves undisturbed the infection in the seminal vesicle and that consequently recurrent infection is not prevented. He advises puncture of the vas and injections through it into the vesicle.

Method I.—Through a scrotal incision expose the vas and lift it out of its sheath in which it normally slides freely like a tendon. Pass the handle of a scalpel behind the vas to support it outside the skin wound. Open the small lumen of the vas and inject as in Method II.

FIG. 911.—(*Belfield, Jour. A. M. A.*)

Method II.—*Step* 1.—With the fingers press the vas against the lateral wall of the scrotum and fix it there by tenaculum forceps (Fig. 911) applied about one-half inch apart. Apply gentle traction to the forceps to make tense the tissues over the vas. Expose the vas through an incision one-half inch long.

Step 2.—Puncture the lumen of the vas with the point of a knife, sufficiently to introduce a fine thread of silkworm gut. Introduce this thread in the direction *away* from the epididymis. Thread a blunt hypodermic needle or its equivalent, over the thread and so guide it into the lumen. Remove the guiding thread.

Step 3.—Slowly inject through the needle 10 c.c. methylene blue solution (1 : 25,000). This should cause a desire to urinate. If the urine passed is not stained blue, an error in operation has occurred and must be corrected or the operation abandoned. Belfield has found the vas occluded in more than 1 per

cent. of his operations. If the second vas is operated on at the same sitting, Fuchsin should be used as the test injection. When stained urine has proved correct operation and patent duct, slowly inject 20 cc. collargol solution (5 per cent.) and after two minutes inject 1 c.c. water. This last is done to lessen the chance of the collargol escaping through the puncture wound.

Step 4.—Reintroduce a strand of silkworm gut through the needle into the duct. Withdraw the needle. Thread a sharp hypodermic needle over the strand of silkworm gut and thus guided push it into the lumen. Make the point of this needle pass through the wall of the vas and out through the skin at a point about one-half inch distant from the original puncture. Withdraw the needle leaving the thread with its ends projecting from the skin. Do not tie the ends of the thread together. The thread acts as a drain and also as a guide for the introduction of the blunt needle, should further injection be required. Remove the thread within five days.

Operative Treatment of Undescended and Misplaced Testicle.—There are several types of undescended and misplaced testicle. The testis may be situated (*a*) in the abdomen near its original position; (*b*) at the internal ring; (*c*) in the inguinal canal; (*d*) outside the external ring; (*e*) in the perineum; (*f*) on the thigh below Poupart's ligament.

No matter where the testis is located, the principles of treatment are identical. These principles are: (1) Proper exposure of the organ. (2) Thorough relief of tension so that the organ may be brought into the desired place (the scrotum) and may tend to stay there of itself. (3) Proper preparation of the bed in which the testis is to lie. (4) Selection of proper time for operation. Undoubtedly the changes incident to puberty will take place more completely in the testicle when it lies in its natural position in the scrotum; hence the age of selection for operation is before puberty, when the patient is from six to twelve years old.

A. D. Bevan ("Jour. Am. Med. Assoc.," Sept. 19, 1903) has thrown much light on the condition under discussion, and the following paragraphs are based on his writings:

(A) The testicle is in the inguinal canal or outside the external ring.

Step 1.—Make an incision from the external ring upwards and outwards for a distance of three inches. This incision is like that made in Bassini's operaton for inguinal hernia and does *not* involve the scrotum. Divide and retract the aponeurosis of the external oblique as in the hernia operation. Divide the cremasteric and thin transversalis fasciæ throughout the length of the wound.

Step 2.—Note the peritoneal pouch containing the testicle. Open this pouch and expose the testicle. Divide the peritoneum above the testicle and carefully separate it from the cord, as in a hernia operation. Close the stump of peritoneum by suture or ligature. With a purse-string suture close the portion of peritoneal sac in contact with the testicle and so form a tunica vaginalis (Fig. 912).

Step 3.—Lift the testicle out of its bed. Pull gently on the cord to lengthen it as much as possible. Shortened bands of connective tissue will be seen as [redacted]nds in the cord. Tear through these bands with forceps. Strip the

cord of all the surrounding fascia, leaving nothing but the vessels and the vas. Separate the spermatic vessels and vas, which lie behind the posterior layer of peritoneum of the abdominal cavity, from the peritoneum by blunt dissection. "The spermatic vessels will be found passing upwards and inwards, and the

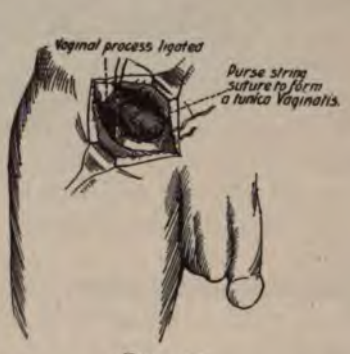

FIG. 912. FIG. 913.

FIGS. 912 AND 913.—Bevan's operation. (*Bevan.*)

vas downwards and inwards from the internal ring." The above manœuvres should so lengthen the cord that the testicle may be laid on the thigh three or four inches below Poupart's ligament (Fig. 914). Unless lengthening of the cord is obtained to the extent mentioned, other measures must be adopted to secure the requisite relief of tension.

FIG. 914.—Bevan's operation. (*Bevan.*)

Step 4.—Pass the fingers from the wound into the scrotum and form a pocket there. Into this pocket tuck the testicle. Close the mouth of the pocket by a purse-string suture passing through both the external and internal pillars of the external abdominal ring, above the cord. Do not let the suture exercise pressure on the cord.

Ombrédanne ("La Presse Med.," Oct. 8, 1910) passes a finger from the wound into the bottom of the scrotum on the same side and then pushes the finger transversely through the septum into the other side of the scrotum where he incises the skin (Fig. 915). A forceps passed through the scrotal skin wound follows the finger as it is withdrawn to emerge at the inguinal wound where it grasps a suture inserted into the tunica vaginalis formed in Step 2. By pulling on the suture the testicle is pulled through the septum to the opposite side of the scrotum, where it is easily fixed by a few stitches.

Step 5.—Close the wound as in a Bassini operation, but instead of dislocating the cord, sew the conjoined tendon and Poupart's ligament together above, *i.e.*, superficial to the cord.

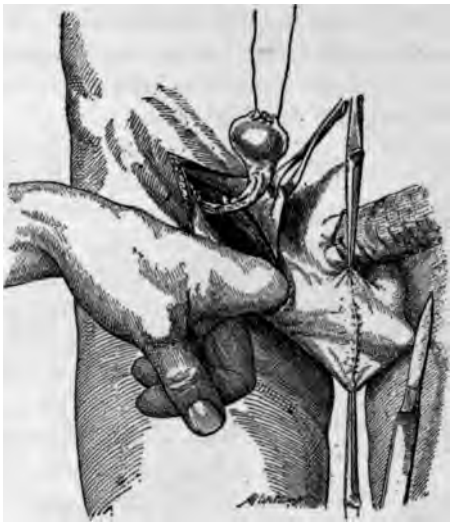

FIG. 915.—Ombrédanne's operation. (*Ombrédanne.*)

(B) Where it is impossible to get the requisite lengthening of the cord by the means described in Step 3, or when the testicle is intra-abdominal, the following measures suffice: Open the inguinal canal. Expose the testis; if necessary, "hook" it out of the abdominal cavity with the finger. The obstacle to the descent of the testicle is not the vas, but the spermatic vessels. Division of these does no harm to the testis. This was pointed out many years ago by Bennet, and agrees with the writer's experience. The testicle gets a sufficiency of nourishment through the artery of the vas. Doubly ligate and divide the spermatic vessels (Fig. 913). When this is done, it is easy to bring the testicle down into the scrotum.

CHAPTER LVII

HYDROCELE

Tapping a Hydrocele.—Clean the scrotum. Ascertain the position of the testicle by palpation; the patient's sensations aid, so does the translucency test. Place the left hand behind the scrotum and grasp it so as to render its anterior surface tense. Choose a point on the lower anterior surface free from veins and at this place thrust a trocar and cannula upwards and backwards to a depth of about one inch. Avoid thrusting towards the testicle. Withdraw the trocar and let the fluid escape through the cannula, keeping up pressure with the left hand. When the fluid is all evacuated withdraw the cannula. Dress the puncture with collodion or leave it to the care of nature which is usually equally good.

Radical Cure of Hydrocele.—I. *Injection Method.*—A. *Iodine Injection.*—Tap the hydrocele completely. Inject through the cannula about half an ounce of tincture of iodine. Withdraw the cannula. Rub the scrotum gently between the hands to insure even distribution of the iodine throughout the sac. Within twenty-four to thirty-six hours there is much swelling and pain in the scrotum but this soon subsides. After two or three weeks recovery ensues though a suspensory bandage is often required for some time.

FIG. 916.—Jaboulay's operation. (*Duval.*)

B. *Carbolic Acid Injection.*—Tap and inject about ten drops of liquefied carbolic acid in the same manner as with iodine. It is difficult to inject through the cannula such a small quantity of liquid, hence the following method is better. By tapping withdraw most but not all of the liquid. Charge a hypodermic syringe with the carbolic acid. Puncture the hydrocele with the hypodermic needle until the needle touches the cannula, thus making sure that its point is really inside the sac. Permit the rest of the hydrocele fluid to escape through the cannula. Withdraw the cannula. Discharge the hypodermic syringe and withdraw it. The results of injecting carbolic acid are as good and less painful than when iodine is used. The author cannot recommend the injection method of treatment. It is less sure, more painful and less free from danger than is open operation.

II. *Incision.*—Volkman's operation. Make an incision, not less than 1½ inches long, into the sac. Suture the wound in the sac to the skin. Drain with tube or gauze. Apply dressings.

III. *Excision.*—Bergmann's operation. Through the skin make an incision extending from near the upper to near the lower end of the hydrocele. Expose the sac and by blunt and sharp dissection separate it from its coverings until

its connections with the testicle are reached. Open the sac and trim it off close to the testicle. Attend to hemostasis. Close the wound with or without drainage. In scrotal wounds the writer usually inserts a *very few* interrupted sutures between which it is easy for fluids to escape. Apply dressings and support the scrotum.

IV. *Eversion of Hydrocele Sac.*—Jaboulay's operation. Make an incision into the hydrocele. Bring the testicle out through the wound. Ligate and divide the gubernaculum testis. Fold the two sides of the divided sac behind the testicle and fix them there by a few sutures, one of which must interest the superficial tissues of the cord. Reduce the testicle. Close the scrotal wound by a few sutures (Fig. 916). This is a very satisfactory, easy and rapid operation.

Hydrocele of the Cord.—A. Small hydroceles or cysts of the cord. Expose the sac by an incision almost as long as itself. Pick up the upper end of the sac in the fingers and remove it if possible unbroken by gauze dissection.* Close the wound.

B. Hydrocele of larger size than the preceding.

(*a*) Incise and drain.

(*b*) Excise most of the sac wall.

(*c*) Eversion method. Incise. Turn the walls of the sac back and fix with sutures on the other side of the cord.

CHAPTER LVIII

VARICOCELE

Open Operation.—*Step* 1.—Make an incision parallel to and directly over the cord. The incision should be 1 to 1½ inches long and its upper end correspond to the external abdominal ring. Layer by layer divide the tissues until the cord is exposed.

Step 2.—Pick up the whole cord and isolate it from the external abdominal ring to the testicle. This is easy. Recognize the vas which feels like whipcord. Separate the vas and with it a very few veins, from the rest of the structures forming the cord and hold it aside.

Step 3.—Apply a crushing forceps near the external abdominal ring to the mass of veins to be removed. Similarly apply a crushing forceps or clamp to the same mass of veins near the testicle. Remove the crushing clamps. Tie catgut ligatures round the veins in the grooves left by the clamps. Cut away the veins between the ligatures leaving sufficient stump to prevent slipping of the ligatures. The only objects in using the crushing clamps are to provide a groove in which the ligatures can lie and to permit the use of a finer thread than would otherwise be necessary.

* Gauze dissection. Blunt dissection may be carried out with instruments or with the fingers. If a "sponge" or "wipe" of gauze is used over the tips of the finger the dissection is more satisfactory. This constitutes gauze dissection.

Step 4.—Bring the two venous stumps together and keep them together by a stitch or by tying the upper to the lower ligature.

Step 5.—Close the wound with or without drainage.

Remarks.—The incision is made at the level of the external abdominal ring because at this place (*a*) it is easy to isolate the cord, (*b*) it is very easy to apply dressings after the operation.

On recovery, a suspensory bandage ought to be worn for some months. The junior surgeon may be warned that a hard swelling about the testicle usually persists for a few weeks after healing, which may alarm the patient unless he is warned of the possibility before hand.

R. Frank's Operation ("Zent. f. Chir.," iv, April, 1914).—Frank avoids ligation and resection of the veins with consequent fibrous degeneration of the parenchyma of the testicle.

FIG. 917.

Expose the fascia of the external oblique and the external inguinal ring exactly as in an operation for hernia. Strengthen the external inguinal ring with a stout stitch. Do *not* divide the fascia propria or the tunica vaginalis. Pull the testicle up out of the scrotum to the bottom of which it is attached by the gubernaculum. Divide the gubernaculum between forceps; ligate the scrotal stump but leave the forceps atached to the testicular stump. From the apneurosis of the external oblique reflect downwards a flap (pedicle at the external ring) 5 cm. (2 in.) long and 2–3 cm. (¾–1¼ in.) wide. Suture the distal end of the aponeurotic flap to the testicular stump of the gubernaculum (Fig. 917). The length of the fascial flap must be sufficient to support the testicle in its physiological position just under the root of the penis. Reduce the testicle into the scrotum. Close the wound. The testicle now lies upside down in the scrotum.

PART V.—THE SPINE

CHAPTER LIX

OPERATIONS ON THE SPINE

It is important to recognize certain easily remembered relations which exist between the spinal cord and the spinous processes. These relations are thus described by Chipault: (Fig. 918.)

(*a*) The terminal cul-de-sac of the dura mater corresponds to the fifth lumbar interspinous space.

(*b*) The inferior limit of the spinal cord is situated in men at the level of the first, in women, of the second, in infants, of the third, lumbar spinous process.

(*c*) The cervical segment of the cord terminates at the level of the sixth cervical interspinous space; the dorsal, at the ninth dorsal; the lumbar, at the inferior border of the twelfth dorsal spine; the sacral segment ends at the superior border of the first lumbar spine.

(*d*) The relations of the summits of the spinous processes to the nerve roots may be expressed by a simple formula which, while not mathematically correct, is sufficiently so to act as a guide in surgical intervention.

For adults the formula is: In the cervical region to find the nerve which emerges at the level of the individual spinous process, add the numeral one to the number of the process, *e.g.*, it is the third cervical root which emerges opposite the second spinous process. In the superior dorsal region add the numeral two to the number of the process. From the sixth to the eleventh dorsal processes add the numeral three. The inferior part of the eleventh dorsal spinous process and the subjacent interspace correspond to the origin of the sacral nerves.

For children under the age of six or seven years the following modification of the formula holds good: In the superior dorsal region (from the first to the fourth apophysis) add three to the number of the spinous process to obtain the number of the corresponding nerve root; in the mid-dorsal region (fifth to ninth apophyses) add the numeral four.

LUMBAR PUNCTURE

Lumbar puncture is the operation by which the lumbo-sacral cerebro-spinal cistern is tapped.

Objects of the operation. (*a*) Diagnostic: Observation of the tension, the

chemical composition, the freezing point, the cellular composition, the bacteriology of the fluid and the permeability of the meninges to chemical substances introduced into the blood. (*b*) Therapeutic: Relief of cerebro-spinal tension. (*c*) A step in the production of spinal anesthesia.

One must remember that there is no means of knowing whether the fluid obtained by puncture in any individual case is from the subarachnoid or the subdural space (Ballance).

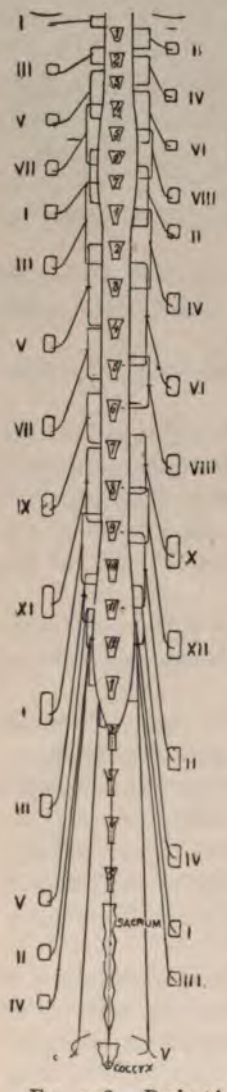

FIG. 918.—Relation between spinal cord and spinous processes. (*Poirier and Charpy.*)

The commonest site for the puncture is between fourth and fifth lumbar vertebræ, though Chipault thinks the lumbo-sacral space better as it is larger, surrounded by good landmarks and is opposite the terminal enlargement of the dural sheath.

Puncture in fourth lumbar interspace.

It will be most convenient to describe the operation as performed for the production of spinal anesthesia.

Step 1.—Seat the patient with his legs and arms hanging in front and body bent well forwards. Clean the whole lower part of the back. Palpate the crest of the iliac bones; note their high points; join these points by a line. This line bisects the fourth lumbar space (Figs. 919, 920). Place and keep a finger on the point of the fourth lumbar spine.

Step 2.—Take a hollow needle about 3 inches long and about $\frac{1}{32}$ inch (1 mm.) in diameter. Probably Dawbarn's is the best needle. Introduce the needle about $\frac{3}{4}$ inch from the middle line and slightly below the spinous process. Push the needle slowly and steadily forwards and slightly inwards until the cerebro-spinal

FIG. 919.—Spinal puncture. (*Marion.*)

fluid escapes drop by drop. If the operation is performed for diagnosis or relief of tension collect the fluid in sterile test-tube. In children the needle must usually penetrate 1 to $1\frac{1}{4}$ inches, in adults $1\frac{1}{2}$ to $2\frac{1}{2}$ inches or more.

Step 3.—As soon as the liquid begins to escape fix a hypodermic syringe to the needle. The syringe should contain the sterilized powder to be injected (tropacocain; stovain; novocain). Slowly withdraw the piston of the syringe and thus draw cerebro-spinal fluid into the syringe. As soon as the fluid has dissolved the powder reinject slowly. Remove the needle. Dress the puncture wound with collodion. The operation may be performed with the patient in the lateral posture, lying down with the back thoroughly flexed.

FIG. 920.—Spinal puncture. (*Marion.*)

SPINAL MENINGITIS

The operative treatment of spinal meningitis is in its infancy. A case reported by Kümmel ("Archiv für klin. Chir.," lxxvii, 938) gives hope for the future. A sacral tumor had been removed from a woman, aged twenty-seven; a fistula resulted and became infected; an extensive pelvic phlegmon formed; the patient became very restless and stupid, later comatose. Pulse 160. Temp. 105°. Cerebro-spinal meningitis was clearly present. By lumbar puncture there was drawn off cloudy purulent fluid which was under pressure. In spite of the desperate condition of the patient, the spinal canal was opened from the fistula up to the second lumbar vertebra; bad-smelling pus escaped; the discolored dura was widely opened; the arachnoid was injected and infiltrated with pus.

The patient regained consciousness, headache disappeared, vomiting ceased, spinal rigidity almost vanished. Owing to extreme weakness the patient died within forty-eight hours. The autopsy showed extensive suppurative cerebro-spinal meningitis; pelvic phlegmon and peritonitis; pericarditis. This case, in spite of its fatal outcome, is encouraging.

Murphy formulates the indications for operative intervention in acute meningitis as follows:

"1. Lumbar spinal puncture for the diagnosis as well as for the relief of cerebro-spinal tension. Large quantities of fluid may be withdrawn at in-

dividual sittings in this way, and the sittings may be as frequent as the symptoms of cerebral pressure recur. A cannula with a double opening at its lower end may be substituted for the needle in cases of rapidly recurring cases of hyperpressure. This must be very cautiously protected against the entrance of air and micro-organisms.

"2. Continuous drainage of the spinal canal with secondary drainage of the ventricles may be established by a single laminectomy with the insertion of a very small tube. This, however, will be rarely indicated if the cannula is used judiciously and to its best purpose.

"3. Ventricular drainage, transoccipital, can be made through a musculocutaneous flap with a trephine opening in the occipital bone to the right or left of the median line, an inch posterior to the foramen magnum. The dura may then be excised, the bony opening enlarged, if necessary, with bone-forceps, the velum exposed, opened if indicated, or the tube may be inserted in the subarachnoid space without opening the velum. This can be utilized in connection with spinal puncture or laminectomy.

"4. Transparietal ventricular drainage can be established by following the description given in the average work on surgery for the insertion of the tube into the lateral ventricles. A small trephine opening is all that is necessary for this procedure. It is an operation that will be rarely undertaken, as lateral ventricular is the least common of the meningeal infections. The duration of the drainage is governed by the general surgical principles of drainage. I prefer rubber to the metallic type of drain."

Operation for Acute Lepto-meningitis.—*Drainage and Spinal Irrigation.*—Place the patient in a position with maximum flexion of the lumbo-sacral region.

Step 1.—Make a three-inch longitudinal incision on *each* side of the sacrum, following the lines of the postero-external tubercles. Unite the lower ends of the incision by a curved transverse cut at the level of the last sacral tubercles. Reflect upwards the U-shaped flap until the sacral foramina are exposed.

Step 2.—With bone-forceps divide the sacral laminæ from below upwards until the dura is exposed at the third body. This portion of the dura forms the lower boundary of sacral cerebro-spinal cistern. Attend to hemostasis.

Step 3.—Make a small longitudinal incision through the dura. Permit the escape of enough fluid to relieve tension. Close the dural wound with a hemostat. Temporarily cover the wound with dressings.

Step 4.—Make an incision parallel to and below the occipital ridges *on one side* down to the bone. From the inner end of this incision make a median cut downwards to within ½ inch of the foramen magnum. Reflect the soft parts. Open the skull near the middle line over one cerebellar fossa.

Step 5.—Make a small opening through the dura into the cerebellar cistern. Introduce a blunt cannula, such as is used in the intravenous infusion of salt solution. Attach an irrigator charged with salt solution to the cannula.

Step 6.—Remove the forceps from the dural opening at the sacrum. Permit salt solution to flow through the cannula into the subdural space, through

the spine and out through the sacral wound. To demonstrate that the salt solution introduced above is escaping below Murphy suggests coloring it with carmine.

Step 7.—Insert rubber drainage-tubes into both the upper and lower openings. Close the wounds around the tubes. Regulate the cerebro-spinal tension by clamps applied to the tubes.

Murphy, who has systematized the above operation, writes: "The irrigation may not be needed, as a simple drainage with relief of pressure or pus tension is often all that is needed to conduct to a cure. It is the tension that favors absorption and tissue necrosis, and tiding over the primary acute pressure of the products of infection is life-saving."

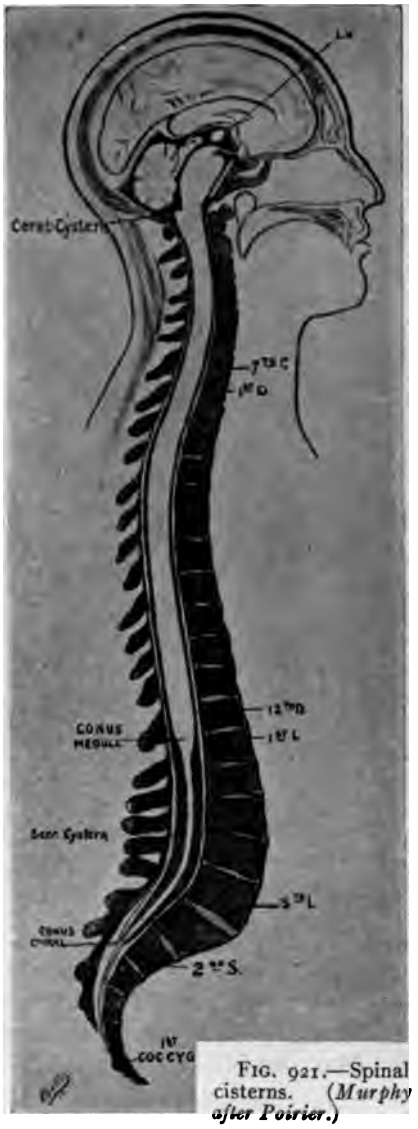

FIG. 921.—Spinal cisterns. (*Murphy after Poirier.*)

LAMINECTOMY

Laminectomy is the operative means by which the spinal canal is opened for exploratory or therapeutic purposes.

Method A.—Step 1.—Make a vertical median incision over the spinous processes. This cut reaches directly to the spinous processes, and is at least four inches in length.

Step 2.—On one side of the spine separate by sharp and blunt dissection the muscles from the side of the spinous processes and from the back of the laminæ of the vertebræ. Bleeding is usually severe. Quickly pick up the bleeding vessels with forceps and pack the wound with gauze wrung out of very hot water. Separate the muscles on the opposite side in the same way.

Step 3.—Choose the point at which to enter the spinal canal. Divide the interspinous ligament. Cut away the spinous processes with bone-cutting forceps. Proceed to the division of the laminæ for which several methods are available: (*a*) Apply an osteotome to the lower edge of the lamina and with blows of a mallet drive it through the bone. It is important to keep the long axis of the osteotome parallel to the plane of the bone lest the instrument penetrate and injure the contents of the canal. It is also important to have the

bone incision at right angles to the lamina, otherwise the instrument may cut its way into the pedicle of the vertebra and much time be lost (Fig. 922). Having divided one lamina divide the lamina on the opposite side of the same vertebra and remove the bone. The laminæ of the vertebræ above and below may be divided as required with osteotome or with forceps.

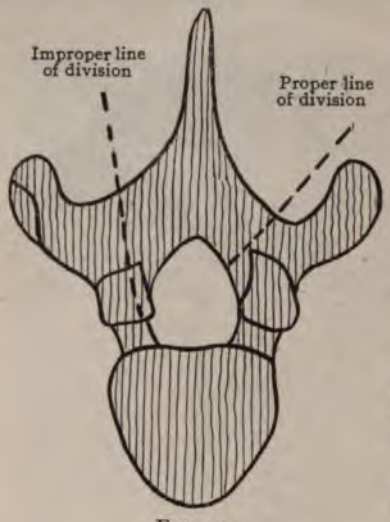

FIG. 922.

(*b*) Perforate a lamina with Doyen burr or with a trephine and complete its division with forceps (Keen's; "De Vilbiss," etc.).

(*c*) Divide the laminæ with a saw. (Hay's, "MacEwen's, Doyen's.")

Step 4.—Inspect carefully the contents of the spinal canal. Examine the anterior as well as the posterior surface of the cord. The cord may be gently pulled to one side without damage resulting. Note the condition of the posterior surface of the vertebral bodies.

Carry out any therapeutic measures which may be indicated. If it seems necessary to open the dura mater, do so, and close the opening with fine catgut sutures. Having completed the exploration or whatever operative measures may have been necessary, close the external wound by deep and superficial sutures, with or without drainage. Generally drainage during the first twenty-four hours is advisable. Apply the usual dressings and carry out subsequent treatment on the ordinary principles of surgery.

Method B.—Frazier's Method.—To increase insurance against infection and to arrest promptly the flow of cerebro-spinal fluid when the meninges have been opened Frazier divides the skin, fascia and muscles in different planes.

FIG. 923.

Step 1.—Reflect a skin flap, A B C D (Fig. 923), so as to expose the desired area.

Step 2.—Make a vertical incision through the aponeurosis a little to one side of the median line and by reflecting the aponeurosis slightly from the deeper structures gain access to the muscles on each side of the spinous processes.

Step 3.—Separate the muscles from the spinous processes and laminæ in the usual manner.

In closing the wound suture the different structures separately.

Method C.—Urban's Osteoplastic Method.—Make a **U**-shaped incision around the area of spine to be attacked. Through the vertical limbs of the **U** expose and divide the vertebral laminæ with chisel, saw, or forceps. Divide

nterspinous ligament opposite the transverse part of the **U** cut. Expose spinal canal by reflecting the **U**-shaped flap which contains, besides the and soft structures of the back, the spinous processes and part of the ebral laminæ. (Fig. 924). The rest of the operation is the same as in hod A.

Method D.—Abbé's Osteoplastic Method.—Make an incision through the parts about ½ inch to the side of the spinous processes. Expose one side

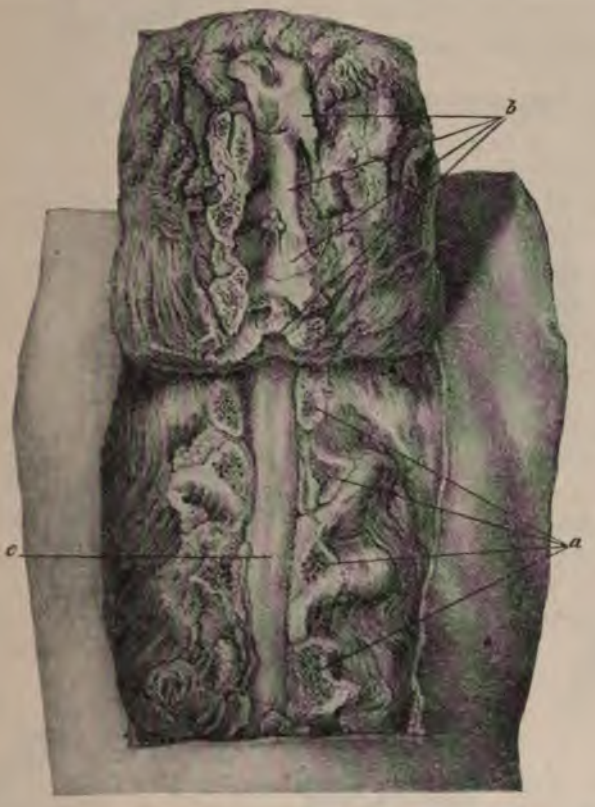

FIG. 924.—Osteoplastic laminectomy. (*Urban, Archiv für Klin. Chir.*)
a, Divided laminæ; *b*, post. wall of spinal canal reflected in flaps; *c*, cord.

e spinous processes. With a chisel or osteotome divide the spinous proc- near the laminæ. Turn the spines back along with the soft parts as a on the other side of the wound. Proceed with the laminectomy.

Method E.—Röpke's Temporary Laminectomy.—("Zentralblatt für Chir.," , No. 33.)

Step 1.—Make a longitudinal incision over the spinous process of the selected ebræ. Separate the soft parts on each side from these processes and down eir bases. Remove each spinous process by cutting it at its base with a forceps.

Step 2.—With a wide chisel applied to the osseous wound cut off a slice of

bone incision at right angles to the lamina, otherwise the instrument may its way into the pedicle of the vertebra and much time be lost (Fig. 9 Having divided one lamina divide the lamina on the opposite side of the s vertebra and remove the bone. laminæ of the vertebræ above and b may be divided as required with osteot or with forceps.

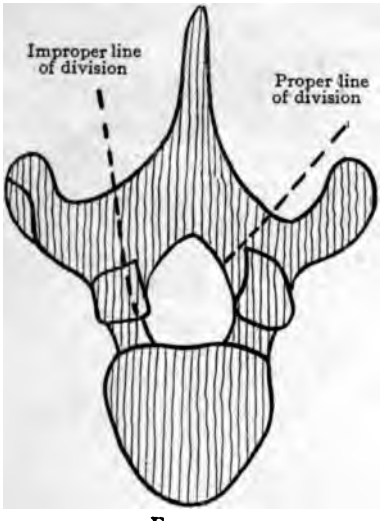

FIG. 922.

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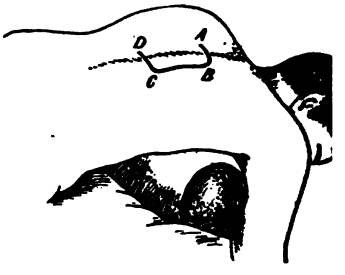

FIG. 923.

Step 1.—Reflect a skin flap, A B C D (Fig. 923), so as to expose the desired area.

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In closing the wound suture the different structures separately.

Method C.—Urban's Osteoplastic Method.—Make a U-shaped inci around the area of spine to be attacked. Through the vertical limbs of U expose and divide the vertebral laminæ with chisel, saw, or forceps. Di

FIG. 925.—Röpke's method.

FIG. 926.—Osteoplastic laminectomy. (*Marion.*)

FIG. 927.—Division of spinous processes. (*Marion.*)

each lamina (Fig. 925) and retract these mobilized portions of laminæ along with the soft parts.

Step 3.—With a chisel or rongeur forceps excise the remaining portions of the laminæ. This gives free access to the spinal cord. Röpke in one case was able to remove two tumors from the sides of the cord and one from inside the cord itself.

Step 4.—After completing the operation on the cord and suturing the dura, replace the bone-periosteal flaps and close the wound with sutures.

To the author it seems that Röpke's operation will prove useful in cases of tumor of the cord and where division of the posterior nerve roots is indicated (Foerster's operation).

Method F.—Osteoplastic Method of Cavicchia and Durante.—This method, very similar to Abbé's is most highly recommended by Marion.

Step 1.—Make a slightly curved incision (Fig. 926) to outline a skin flap which when reflected will expose the region to be attacked. As in craniectomy it is necessary to open the spine widely to avoid missing the lesion present. A minimum of four arches ought to be opened except in cases of localized osseous lesions; hence a large skin incision is necessary." (Marion.)

Step 2.—Leaving the supra- and interspinous ligaments intact, separate the soft parts on each side from the spinous processes and laminæ. Retract the soft parts. With the chisel as in Abbé's operation divide the bases of the spines or do the same thing by means of special forceps (Fig. 927). Retract the line of mobilized spinous processes which remain attached to each other and to the body by the supra- and interspinous ligaments.

Step 3.—As in Method A. When wound is closed the chain of spinous processes is left in place and is believed to give support to the back.

To the author it seems that the simplest manner of opening the spine is the best. The loss of the laminæ of four vertebræ does not seem to appreciably lessen the stability of the spine.

TUBERCULOUS PARAPLEGIA

A tuberculous lesion situated in the body of a vertebra (usually lower dorsal or upper lumbar) may spread backwards and form a tuberculoma which presses on the *front* of the cord. The cord is usually bent and flattened but for a long time there may be no trophic or degenerative changes in the cord. In a case favorable for operation the disease is practically an extra dural tumor on the posterior surface of the vertebral body and hence the early paraplegic symptoms are purely motor. Operation is indicated *before* degeneration of the cord becomes established and after proper treatment by hygiene and immobilization has failed. According to Gowers paralysis due to vertebral caries is the most favorable of all types of paralysis.

Operative Treatment.

Step 1.—Open the spine by laminectomy. Do *not* open the meninges.

Step 2.—Displace the cord to one side. Expose the granuloma and thoroughly remove it with the curette. Dry the bone cavity carefully and fill it with a Mosetig-Moorhof bone plug.

[Iodoform, 60; spermaceti and oleum sesami, āā, 40; heated slowly to 100° C. in a flask on a water-bath; kept at this temperature for fifteen minutes, then removed and allowed to cool and solidify, while shaken constantly. Before using, melt and heat to 50° C. in a thermostat.]

If the wound heals without suppuration and operation has not been too long delayed, the paraplegia rapidly disappears.

Harte ("Trans. Am. Surg. Assoc.," 1905) has collected records of ninety-two operations for spinal tumors with a total mortality of 47 per cent.; the mortality due to the operation was, however, only 28 per cent. Even when a cure could not be obtained relief from pain was almost always secured. The large number of sarcomata removed and the striking absence of recurrence exhibited (seventeen out of thirty-seven) makes it probable either that there was a mistake in the histologic diagnosis or that sarcomata in this region are of comparative benignity.

In some of Harte's cases the symptoms of tumor were due to meningeal thickenings or adhesions. In the discussion of Harte's paper J. C. Munro stated: "In a number of cases that I have had—cases of syringomyelia and of chronic fracture—I have found that which at one time was denied by pathologists, a definite, localized collection of clear fluid in the subarachnoid space which produces by its presence more or less complete paralysis. By opening this small sac of fluid the symptoms may be absolutely relieved." These remarks of Munro's are quoted here because they bear out remarkably some observations of F. Krause (Proceedings, "German Surg. Soc.," 1907). Krause has opened the spinal canal twenty times for tumor-like symptoms, and has found tense subdural collections of fluid eight times. On section of the dura the fluid forced itself out and the arachnoid protruded in bladder-like manner through the dural wound. Adhesions existed between the dura and the pia. The disease is a local collection of fluid in the arachnoid and has been named meningitis serosa spinalis. The results obtained from evacuation of the fluid and closure of the wound have been good.

In operating for tumors one must remember the tendency to locate the tumors at a lower level than that at which they actually exist and that therefore, if no growth is found on opening the spine, one should remove the laminæ of one or two higher vertebræ.

TUMOR OF THE SPINAL MENINGES

Expose the spinal canal by Method A. If the tumor is external to the meninges extirpate it, being careful to avoid injury to the nerve roots. If any nerve leaving the cord is divided, it should, if possible, be immediately reunited by suture. The posterior surface of the meninges is generally separated from the bone by a collection of fat containing many veins; thus hemorrhage may be troublesome, but this can be readily stopped by packing with strips of gauze wrung out of very hot water. When the tumor is inside the dura, that membrane must be divided, the limits of the growth defined, and its removal effected by careful blunt dissection. After attending to hemostasis the wounded dura may be sutured or not, according to indications.

Tumors of the cord itself are not amenable to surgical treatment.

INJURIES TO THE SPINE

It is extremely difficult to lay down precise rules for guidance as to when and when not to operate in injuries of the spine and spinal cord. J. B. Murphy has formulated certain guiding principles, of which an abstract is here given:

A. Paralysis from contusion may be due to "traumatic zonal inflammation," may have no initial symptoms and may only develop days or even weeks after the injury. Such cases are more liable to be cured without than with surgical intervention.

B. When *immediately* after the injury there is *uniformly transverse, complete* paralysis of motion and sensation operation is useless, as the cord is completely divided and regeneration is impossible.

C. Fracture of the spine is present, but there is no great displacement. Paralysis appears hours, days or weeks after the injury. The paralysis is *not* complete and annular of both motion and sensation. It is impossible to diagnose whether the cord lesion is due to contusion or to pressure. Murphy advises strongly against operation.

D. If under the above circumstances (C) there is marked displacement it is proper to diagnose compression, and immediate operation is indicated.

E. Fracture of the spine is present below the twelfth dorsal vertebra. The rules given above no longer apply. At the twelfth dorsal vertebra the spinal cord ends and the cauda equina begins.

"The cauda equina, which begins here, is made up of essentially peripheral nerve fasciculi, and not of spinal cord fasciculi, as the axones of the motor root in this portion have their ganglion trophic cells above this level in the conus, and the motor axones in the cauda are covered with the sheath of Schwann, or neurilemma. They therefore degenerate after division, and have the power of regenerating, the same as peripheral motor axones. The sensory neurones of the posterior roots of the cauda have their ganglion cells just inside the sacral and lumbar foramina. Their proximal axones, which run through the cauda to the spinal cord are medullated, and have a sheath of Schwann. They are capable of regenerating, at least up to the posterior commissures, and from clinical observation, we believe, can again functionally contact with the posterior horn of gray matter. In other words both the motor and sensory neurones in the cauda outside of the cord are histologically capable of regeneration under favorable conditions; that is, after accurate suture and exact approximation of the ends of the divided caudal fasciculi under aseptic conditions."

Every case of fracture of or injury to the spine in the lumbar reigon accompanied by paraplegia demands operation. Causes of compression must be removed; divided fasciculi must be united by suture. "It is easy to determine which are the right and left fasciculi by a mild faradic current up to the seventh day after the injury."

F. In cases of bullet wound of the spine, when the bullet is shown by the X-rays to be inside the spinal canal, operation is demanded. Other cases of bullet wounds of the spine should be treated by the rules already laid down.

The principles or rules which have been outlined in the preceding paragraphs are given by Murphy in his classical monograph ("Surg., Gyn. and

Obstetrics," April, 1907) and are the outcome of large experience and untiring study. It would be improper, however, to omit giving the opinions of some other experienced and judicious surgeons. Chipault advises early operation, except when functional disturbance is very slight or shock is very severe. Reduction by extension and local pressure is condemned, as such manœuvres are very liable to press fragments of bone into the cord and increase the damage immensely.

A. J. McCosh advocates early operation before there is time for secondary degenerations to become established. He has seen good follow in cases where the symptoms pointed to total transverse lesions. Mixter and Chase have pointed out that in spite of the absence of conduction, normal fibres may pass through the crushed portion of the cord. Kocher writes, "If one has had Munro's experience, that out of thirty cases of injury to the upper dorsal and the cervical vertebræ one only within ten years lived and had partial restoration of function, while in the same period of time operative treatment resulted in three complete cures, then one will tend to advise operation in every case. The cases must be very carefully examined: if the temperature sinks low (as is often the case in high lesions of the cord) on operation is proper. Munro lost all the patients on whom he operated for acute crushing of the cervical cord. It remains undoubtedly true that we must diagnose irreparable total transverse destruction of the cord in the great majority of patients who exhibit sudden and complete loss of motion and sensation with immediate and total loss of the tendon reflexes; but it is also true that if the transverse lesion is not total then remnants of sensation are present from the first or appear in a few hours or days."

Jacobson ("Operations of Surg.," ii, 1091 ed. 1908) is averse to any surgical interference in cases of fractured spine, owing to the amount of damage to the cord being usually, from the first, irreparable. Thorburn has the same opinion as Jacobson regarding fractures above the level of the first lumbar vertebra; regarding fractures below this level, he advocates surgical interference on the following grounds:

"1. We may here expect a regeneration of the nerve roots, the physiological evidence being strongly in favor of such regeneration, and not against it as in the case of the cord.

"2. The absence of spontaneous recovery in such cases in itself indicates the presence of a mechanical obstacle, such as permanent compression by bone, blood-clot, or cicatrix, otherwise we should expect the roots of the cauda equina to recover as other peripheral nerves after severe injuries."

Burrell ("Trans. Am. Surg. Assoc.," 1915) studied the records of cases of spinal fracture treated in the Boston City Hospital and came to the following conclusions:

"1. That fractures of the spine may well be divided into two classes; first, fractures of the spine with injury to the cord; and, second, fractures of the spine without injury to the cord.

"2. That it is not best to decide what the treatment of an individual case of fracture of the spine should be from the statistics, because the lesion varies so widely.

"3. That in many cases of fracture of the spine it is impossible to primarily state whether the cord is crushed or pressed upon by bone, blood or exudate, except by an open operation.

"4. That only by the persistence of total loss of reflexes, complete insensibility to touch and pain, and motor paralysis below the level of the lesion can total transverse destruction of the cord be diagnosticated.

"5. That if pressure on the cord is allowed to remain for many hours, irreparable damage to the cord may take place.

"6. That unless it is perfectly clear that the cord is irremediably damaged, an open operation to establish the condition of the cord and to relieve pressure is imperative as soon as surgical shock has been recovered from.

"7. That in certain cases of fracture of the spine, when the cord is not injured, but is liable to injury from displacement of the fragments of a vertebra, rectification of the deformity and fixation of the spine may be used.

"8. That if the cord is crushed, no matter what treatment is adopted, there will, of necessity, be a high rate of mortality."

Open the spinal canal by Method A. Remove all blood-clot and severely damaged tissues. Stop bleeding. Examine thoroughly the posterior surface of the cord. Examine the anterior wall of the spinal canal. If there are displacements of bone in this location, interfering with the cord or lessening the calibre of the spinal canal, try to reduce such by manipulations under the guidance of the eye and finger. If manipulations fail, cut away such pieces of bone as threaten the integrity of the cord or jut into the canal. This may be done with the chisel or rongeur forceps. The amount of bone removed may be considerable. Examine the cord once more. If it does not pulsate and presents a distended and bluish appearance, open the dura and clear out the blood-clot which will be found. If the cord is flabby and small, there are probably adhesions existing between the membranes and the cord or between the various nerve roots. This condition calls for the dura to be opened and the adhesions separated.

Any operation undertaken must be done thoroughly. The wound in the dura should be closed, unless this is contraindicated. The external wound is sutured as usual, dressings applied, and the trunk immobilized. Harte and Stewart ("Trans. Am. Surg. Assoc.," xx) report the case of a woman twenty-six years of age who was shot at the level of the seventh dorsal vertebra. Operation showed that the spinal cord was completely severed, a gap of ¾ inch existing between the segments. After removal of lacerated and fragmented tissues the cord was united by three chromicized catgut sutures. Sixteen months after operation "the patient voluntarily flexes the toes, flexes and extends the thighs, and rotates the hips. While sitting the extended leg can be raised from the floor; the patient can slide out of bed into her chair by her own efforts. . . . The bowels move every second day and are under perfect control, except in the presence of diarrhœa."

SYRINGOMYELIA

J. B. Murphy ("Surg., Gyn., Obstetrics," April, 1907) writes:

"While neuropathologists disagree as to the origin of syringomyelia, their findings are uniformly the same. Examination of a cord, even before its section,

reveals a bulging on the posterior half of the cord, which fluctuates on palpation. On section, one or several cavities are found extending upwards and downwards, either for a limited distance or through the entire cord up to the bulb, and occasionally involving the latter. Primarily the cavity is more commonly found in the cervical swelling of the cord. The cavity occupies, almost invariably, one or both posterior horns, just behind the commissure and close to the central canal. The latter is not necessarily dilated, and in some cases is so contracted that it is almost impermeable. Again, the syringomyelic cavity may communicate with the central canal and form one large cavity, impressing one that the condition might be a primary hydromyelia. The tube may be patent or may be subdivided by septa, either lengthwise or laterally, making single or multiple cavities. It may communicate with the fourth ventricle or end near it in subarachnoid space. The shape of the cavity is tubular or triangular, and it is lined with cylindrical epithelium similar to that of the central canal.

"It seems to us, from a theoretical standpoint, that this disease, at least in its circumscribed form, offers a field for surgical intervention. As soon as opportunity presents itself, I will perform a subdural drainage with an inabsorbable seton which will keep a permanent communication between the syringomyelic canal and subdural space, and insure an equalization of pressure, which should stop the advancement of the disease, even if it does not permit restoration of function in some of the compressed ganglion-cells and axones. This operation suggested by Murphy is along the lines of those successfully performed by Sutherland and by Ballance in the treatment of hydrocephalus."

SPASTICITY

Foerster's Operation.—*Operative Treatment of Spasticity and Athetosis. Division of posterior or sensory roots in spastic paraplegia and in the crisis of tabes.* Frazier writes ("Surg., Gyn., Obstet.," Sept., 1910): "If we admit that spasticity or spastic muscular contractures are reflex disturbances, unrestrained by cortical impulses, one way, if not the only way of controlling them, is to remove at least one link in the chain of the reflex arc. Naturally the motor portion of the arc, the anterior horns, the roots, or the peripheral nerves cannot be broken, otherwise the limb would be hopelessly paralyzed; for the same reason the sensory nerves, many of which are mixed nerves, must be left intact, so that by a process of exclusion there remain the sensory roots." (For Sir R. Jones' criticism of Foerster's operation, see p. 774.)

Stubborn cases of radiculitis causing various distressing symptoms may be suitable for Foerster's operation.

Division of the posterior roots was first suggested by Spiller in 1905 ("Journ. of Nervous and Mental Diseases," May, 1905) but Foerster seems to have pushed the matter more vigorously and reported five cases of his own in which Tietze operated. (Foerster, "Zeitschrift für Orthop. Chir.," xxii; Mittheilungen aus "d. Grenzgeb. d. Med. und Chir.," xx; Tietze, Mittheilungen aus "d. Grenzgeb. d. Med. und Chir.," xx.)

A number of different methods of operating have been devised by various surgeons. Tietze and others divide the operation into two stages: first, per-

forming laminectomy and some days later opening the dura and completing the work. Undoubtedly a two-stage operation facilitates the finding of the posterior roots in that there is less blood to obscure the view, but bleeding can be well controlled by pressure with pads of hot gauze against the spinal muscles, and by packing narrow strips of gauze between the dura and the lateral portions of the vertebræ after the spinal canal has been opened. Danger from infection is distinctly less in a one-stage than in a two-stage operation. (For Frazier's method of exposing the cord see p. 760.) To distinguish the posterior roots it is necessary to have free exposure of the posterior surface of the cord; if blood obscures the view it ought to be removed by gentle douching with warm salt solution (Fig. 928).

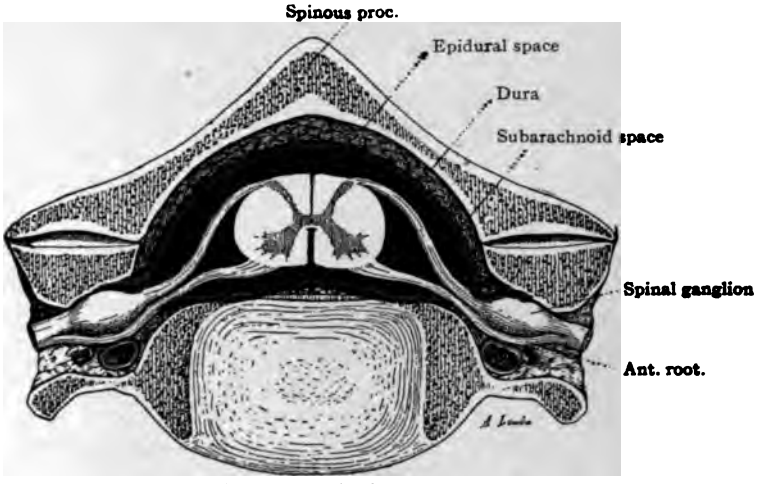


FIG. 928.—(*Poirier and Charpy.*)

After the dura is opened attempts to remove blood by means of sponging are liable to do much damage to the delicate nerve structures exposed.

How many and which of the posterior roots ought to be divided?

Frazier writes: "It is known that the supply of each muscle or group of muscles is represented in most instances by three segments of the cord and by as many roots and, according to the observations of Sherrington, the cutaneous nerve supply of any given area is derived from at least three roots. Theoretically we plan to break the reflex arc of the muscles involved, by cutting off as many peripheral stimuli as possible; we should not, however, remove every source of sensory stimulation, otherwise we would substitute a condition of absolute anesthesia and flaccidity for one of spasticity. In selecting the roots to be sacrificed it is necessary obviously to remove at least two of the three possible sources of sensory stimulation, or, in other words, two of the three roots from which a given group of muscles derives its sensory supply. The following table gives the sensory distribution to the muscles of the lower extremities:

Flexors of the thigh, $L_1L_2L_3L_4L_5S_1$

Extensors of the thigh, $L_5S_1S_2$

Adductors of the thigh, $L_2L_3L_4(L_5)$

Abductors of the thigh, $L_5S_1S_2$
Exter. rotators of the thigh, $L_5S_1S_2$
Int. rotators of the thigh, $L_3L_4L_5S_1S_2$
Extensors of the leg, $L_2L_3L_4$
Flexors of the leg, $L_5S_1S_2$
Dorsal flexors, foot, $L_4L_5S_1$
Plantar flexors, foot, $L_5S_1S_2$

In considering an operation for spastic paraplegia there are seven roots to be considered, namely, the five lumbar and the first two sacral roots. According to Foerster's first dictum at least four roots should be sacrificed and he selected for the lower extremity the second, third, and fifth lumbar and the second sacral, leaving intact the first, the fourth lumbar, and the first sacral.

"The general rule has been not to remove more than two successive roots. If the results of some of the operations have been accurately recorded our views regarding the sensory distribution of the spinal roots may have to be revised. Thus Taylor in one case resected six successive roots, from the twelfth dorsal to the fifth lumbar inclusive, on one side with full retention of sensation, and in another case seven successive roots from the fourth cervical to the second dorsal inclusive, without loss of reflexes. This is absolutely at variance with our present conception of the distribution of the spinal roots and suggests the possibility of the operator having left some fibres undivided. The difficulty in separating the sensory from the motor roots may be attributed to the inadequate exposure of a unilateral opening.

"Whether or not it may be possible to resect a series of five, six, or seven successive roots without permanent disturbance of sensation or reflexes in a given extremity, it is unquestionably true that the desired end may be attained, the spasticity relieved, by resecting four out of seven of the total number of roots supplying a given area. Thus in one of Foerster's cases, one of Gottstein's, and two of my own the spasticity was relieved by resection of three lumbar, or three lumbar and one sacral root.

"On the other hand, if too few roots are resected the results may not be as satisfactory. This was the case in one of Foerster's patients where he resected only the third and fifth lumbar and the second sacral, and in one of my own, where although four successive roots were resected—namely, the fifth, sixth, seventh and eighth cervical—the spasticity was only partially relieved. Therefore, at this juncture it is not possible to lay down any hard and fast rule, suffice it to say that for the lower extremity perfectly satisfactory results have been obtained after resection of the following combinations:

1. $L_2L_3L_5$,
2. $L_2L_3L_5S_2$, or
3. $L_2L_3L_5S_1$.

"For the upper extremity the following combination, $C_4C_5C_6C_7$, was wholly effective in one case (Taylor's third case) while $C_5C_6C_7C_8$ only partially so in another (Frazier's case).

"We may conclude from this that, until further observations are made, the fourth cervical should be included, with or without the eighth."

Immediately after operation pain and spasticity may apparently be in-

creased, just as after amputation of the leg severe pains are experienced and thought to be in the foot which has been removed. Soon such distressing symptoms decrease and disappear. It is necessary, however, in cases of spasticity, to correct deformities which have become established and to institute well regulated muscular exercises.

Foerster's operation ought to be reserved for severe cases of spasticity and of the crisis of tabes.

The published results have been good and the death rate has not been very high considering the gravity of the procedure.

Hofman's Method of Performing Foerster's Operation.—Temporary Laminectomy. ("Zentralblatt für Chir.," 1910, No. 20.)

Step 1.—Make an incision of the desired length over the spinous processes of the vertebræ to be reflected, and separate the musculature by blunt dissection from the spinous processes and from the laminæ on both sides as far as the lateral processes. The sharp bleeding which comes from the muscles is easily controlled by gauze pressure. The periosteum has not been injured.

Step 2.—Divide the laminæ on each side by means of an osteotome held as horizontally as possible.

Step 3.—Divide, transversely, the interspinous ligament either above or below the series of vertebræ attacked, according as the bone flap is to be reflected downwards or upwards. After division of any remaining connections reflect the flap (consisting of periosteum, spinous processes, laminæ and interspinous ligaments) upwards or downwards as may be desired. The dura is now at least partially exposed and can be fully exposed by nipping away some more bone with rongeur forceps. If the chisel is properly applied Hofman claims that injury to the dura or cord is hardly possible. This claim is in full accord with the experience of the late D. J. Hamilton who, in the postmortem room, similarly exposed innumerable spinal cords without injury to their structure.

Step 4.—Incise the dura longitudinally and divide the desired posterior spinal roots.

Step 5.—Close the dural wound by a continuous suture.

Step 6.—Replace the reflected bone flap. Suture the muscles and fascia over the spinous processes. Close the skin wound.

Hofman performed the above operation in one-half hour, which would have seemed totally incredible to the author had he not known of Hamilton's remarkably rapid work in the autopsy room, to which reference has already been made.

(Further information regarding Foerster's operation is to be found in the discussion before the German Surgical Association. "Zentralblatt für Chir.," 1910, No. 31; Codivilla, "Muenchner med. Woch.," lvii, p. 1438; Florcken, "Muenchner med. Woch.," lvii, p. 1441; Bierens de Haan, "Journal de Chir.," Sept., 1910. Discussion, Brit. J. Surg., II, Oct., 1914.)

Stöffel ("La Presse Med.," March 30, 1912) writes regarding the spastic contractures of cerebral hemiplegia or Little's disease "certain muscles and groups of muscles are particularly the site of these spasmodic contractures. (The gastrocnemii, the flexors of the knee, the adductors of the thigh, the pronators and flexors of the hand.) When these muscles are involved, they respond to

stimulation with excessive force; their contraction is violent, exaggerated. They dominate and annihilate their antagonists, they completely upset the muscular equilibrium. * * * The power of voluntary muscular contraction is almost never absent, it is only impeded and masked by the spasm." Foerster's operation is entirely too serious to be considered except in very grave cases.

Stöffel considers that the motor nerves are like telephone cables and contain many filaments, each going without fail to its own muscular fibre or bunch of fibres. Thus any one muscle may be considered as composed of numerous individual muscles (the fibres) each supplied by its own nerve. If a proper number of the individual muscle fibres or bundles of fibres could be paralyzed by division of their nerve filaments, the rest of the muscle being left intact then there would be so much weakening of the muscle as a whole that it could not overpower its antagonists. Such division of nerve filaments may be accomplished at several points on the course of the motor nerve. "The simplest case is where one can expose and follow the nerve to its point of entry into the muscle, *e.g.*, at the upper extremity of the gastrocnemius. At this level the various branches of the nerve are separated and one can easily divide some of them." Where it is impossible to follow the nerve as above, *e.g.*, in the case of the quadriceps and the flexors of the knee, it is easy to expose the nerve, transfix it with a very fine tenotome and divide a very limited portion of it. "If we wish to weaken the *pronator radii teres* we attack the median nerve in the middle of the arm. To weaken the tibiales anticus and posticus we expose the anterior and posterior tibial nerves and section part of their fibres." Stöffel's operation properly carried out "ought to fulfill a double aim to suppress the spastic contracture and to reëstablish at once the function of the muscle which was contracted. The first object is easily attained by complete division of the motor nerve supply, but this completely suppresses the active function of the muscle as well as its contracture and so does not attain the second object of the operation. We ought to divide only part of the nerve supply. If we divide too little the contracture is not removed, if too much, function is destroyed. Can one determine exactly how much of the motor nerve ought to be divided to obtain the exact degree of energy desired in the muscle? To this question I answer affirmatively. By taking into consideration the degree of the contracture, the anatomy and physiology of the contracted muscles, the value of the synergic and of the antagonistic muscles, it is easy to determine how much of the nerve ought to be divided. Practice naturally plays a great rôle in this estimation and as in any new method, one learns in every case. At first one divides too much or too little, but one soon acquires the necessary experience." After operation the antagonistic muscles should be strengthened by gymnastics, massage, electricity, etc. (For Jones' treatment of Little's Disease, see p. 773.)

In spastic contracture of the adductors of the thigh R. Selig (Arch. f. Klin. Chir., ciii, 994) advocates division of the obturator nerve before its entrance into the obturator canal. The fact that the adductor magnus gains part of its nerve supply from the sciatic nerve explains why after section of the obturator nerve, while spastic contraction is prevented, active contraction remains possible. The obturator nerve arises from the second, third and fourth lumbar nerves, crosses the sacro-iliac joint and the internal iliac artery to find its way

g the lateral wall of the true pelvis until it enters the obturator foramen. ts course it follows the lower margin of the horizontal ramus of the pubes a e below the innominate line. The nerve forms a thick palpable cord of easy ss.

Exposure and Division of the Obturator Nerve.—Make a vertical incision about ches in length along the border of the rectus muscle low down. Expose, do not divide, the peritoneum and the transversalis fascia. By blunt dis-

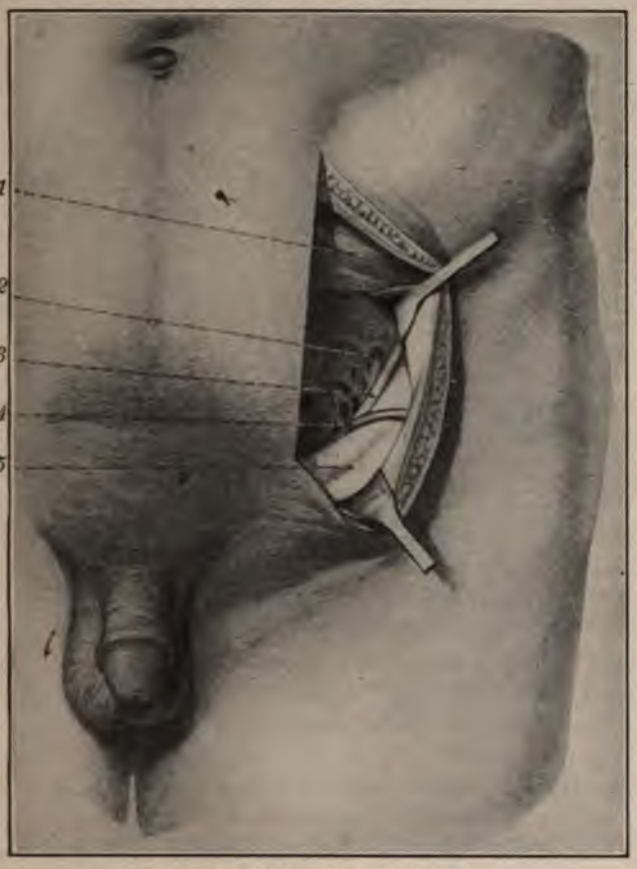


FIG. 929.—(*Selig, Arch. für klin. Chir.*)
eritoneum pushed back. 2. Prevesical space containing connective tissue and fat. 3. Obturator rve. 4. Anastomosis between deep epigastric and obturator veins. 5. Horizontal ramus of pubis.

ion separate the peritoneum from the overlying structures in the lower t of the wound until the horizontal ramus of the pubis is reached. Pass the er behind the horizontal ramus and palpate the obturator foramen. To outer side of the foramen the cord-like nerve can be felt. Fig. 929 shows relations of the nerve. Expose the nerve and divide it. Close the wound n any abdominal operation.

Sir Robert Jones writes (Treatise on Regional Surg., Binnie III, 666): iefly our belief is that the continuance of the state of disability lies in the e contracted over-excitable muscles, and that these are the origin of a con-

tinuous stream of afferent impulses which keep the spinal motor system in a state of excitement and prevent the upper neurone from exercising a proper control, especially inhibitory control. Therefore the attack should be directly on the muscles to put them out of action, so allowing the nervous system to rest. (See chapter on Tenotomy.)

Forster's operation of division of the posterior nerve roots has received much attention in recent years. The idea of the operation is to cut off the afferent impulses from the large spastic muscles and so give the spinal nervous system a rest before commencing re-education.

Our criticism is, first that Forster's operation involves laminectomy and opening the spinal theca is unnecessarily severe; second, we think he is cutting the nerve-muscle cycle at the wrong place, for if our interpretation of Magnus experiments and our deductions from them with regard to spastic paralysis are correct, the fault lies in the state of the muscle.

Our clinical experience is that by putting the spastic muscles out of action, by completely over-stretching them or better by dividing them, we stop the afferent impulses just as effectively as by dividing posterior nerve roots with much less risk to the patient."

SPINA BIFIDA

To understand the operative treatment of spina bifida and the limitations thereof, it is absolutely necessary to have clear notions as to its pathological anatomy. The usual surgical text-books rarely provide such notions, hence the author will try to describe, very briefly, the conditions which should influence operation.

A. **Meningocele.**—A defect of the posterior osseous wall of the spinal canal is present. The skin, spinal membranes, and cord are intact. There is a hernia of the dura through the osseous defect. Fluid in greater or less quantity is present in the dilated subdural space (Fig. 930).

B. **Meningocele.**—The conditions are the same as in A, except that the arachnoid is involved in the hernia and the collection of fluid is in the subarachnoid space (Fig. 931).

C. **Meningocele.**—A defect exists in the dura as well as in the bone. Through these defects there protrudes a hernia consisting of the arachnoid with fluid accumulated in the subarachnoid space. The skin, pia, and cord are intact.

D. **Myelo-cystocele** (Fig. 932).—There exists a defect in the posterior osseous wall of the spinal canal and also in the corresponding portion of the dura. The arachnoid and pia are intact. The central canal of the spinal cord is highly distended by fluid, so that a hernia is formed having the arachnoid and pia as sac. The cord substance is thinly spread out over the inside of the sac—so thinly that in places it is absent. The spreading out of the cord is due to the distention. As will be seen by reference to the diagram, nerve roots run forwards *in* the hernial sac. This is of importance to the operator.

E. **Myelocele.**—A defect exists in the skin, in the posterior osseous wall of the spinal canal, and in the corresponding portions of the dura, arachnoid, and pia. The posterior surface of the cord itself is split or absent. The central canal of the cord is open to the air (Fig. 933). Fluid collects between

pia and arachnoid anterior to the cord, and gives rise to a spinal hernia. will be seen by referring to the diagram, skin is present only at the base the tumor; the hernial sac consists of pia mater with a covering of cord sub-

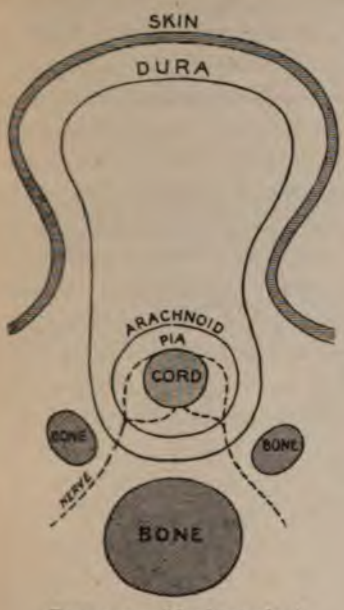


FIG. 930.—Meningocele A.

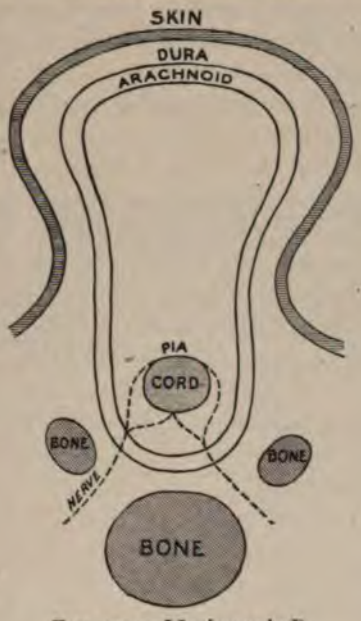


FIG. 931.—Meningocele B.

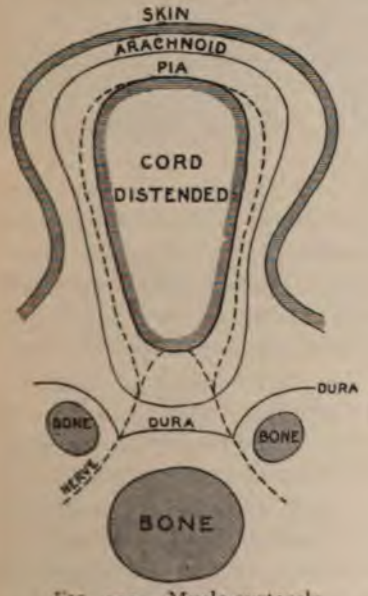


FIG. 932.—Myelo-cystocele.

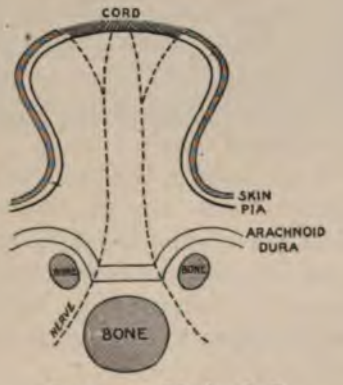


FIG. 933.—Myelocele E.

FIG. 934.—Myelocele F.

ance. The nerve roots run from the cord forwards through the sac. Should collection of fluid form in the arachnoid instead of in front of it, then the achnoid will form part of the hernial sac and the nerve roots will run forwards the sac wall.

F. **Myelocele.**—This form is the same as E, except that there is no collection of fluid (Fig. 934). The remnant of cord substance lies in a groove or depression on the back and is continuous with the skin. The meninges are continuous with the subcutaneous tissues.

The differential diagnosis of myeloceles E and F is easy. They are inoperable.

The diagnosis between myelo-cystocele D and meningoceles A, B, and C is generally impossible, except perhaps, as Horsley has suggested, by applying the electric current and observing its effects. Myelo-cystoceles are more frequently accompanied by other deformities, *e.g.*, club-foot, exstrophy of the bladder, etc., than are meningoceles. The fact that the walls of a myelo-cystocele contain nerve substance, while those of meningoceles do not, makes positive differentiation between the two forms of spina bifida indispensable for scientific treatment. If we inject a solution of iodine (Morton's fluid) into the sac, we may be really throwing it into the central canal of the spinal cord. The injection of iodine has been, until recently, the favorite treatment for spina bifida, but in view of the facts related above one is compelled to believe it unscientific.

Operation is contraindicated in cases of myelocele; in cases of spina bifida accompanied by paralyses or contractures evidencing irreparable defects in the cord substance; in cases of severe hydrocephalus or of abdominal or vesical fistulæ—in all other cases operation is proper.

One must remember that the successful closure of a spina bifida may remove a safety valve from the cerebrospinal system, and that a persistent excess secretion of cerebrospinal fluid may lead to fatal hydrocephalus.

The Operation.—Step 1.—Make two skin-flaps from the base of the tumor, of sufficient size to cover the wound left after removal of the sac. These flaps should be made large rather than small, as it is easy to trim them to suit, before applying sutures.

Step 2.—Having exposed the sac by reflecting the skin-flaps, make an incision into it on one side. This incision should be made transversely and must not reach to the middle lines of the body (*i.e.*, to the apex of the tumor). The reason for these precautions is that most of the medullary tissue, if present, is situated in the middle line, and that the general course of any nerve roots is from the summit of the sac to the base, *i.e.*, parallel to the direction of the incision.

Step 3.—Explore the sac and observe whether nerves lie free in it (Fig. 933) or are enclosed in its walls (Fig. 932). If the nerves lie free in the sac, trace them to their point of origin in the medullary substance which forms part of the sac. Separate the medullary substance, and such of the sac as is united to it, from the rest of the sac and reduce it into the spinal canal. Remove the excess of sac. If the nerves lie in the sac wall, empty the sac of its fluid and reduce it *en masse* after removing all skin from over it. If the case be discovered to be one of meningocele, remove the whole sac after suturing its base.

Step 4.—Close the wound by a series of deep and superficial sutures.

Babcock's Operation.—("Monthly Cyclo. and Med. Bull.," May, 1911.)

Fasten a blanket firmly between the upright rod legholders on an ordinary operating table. Hang the child over this by its groins (Fig. 935) fastening the legs by bandages to keep it from slipping. In front of the blanket place a hot-water bottle opposite the child's abdomen to prevent chilling. Have an assistant at the other side of the blanket to manage the head, watch symptoms and if necessary administer an anesthetic. Sterilize abraded or ulcerated areas with pure carbolic acid followed by alcohol. Paint the whole area with tincture of iodine.

FIG. 935.—(*Babcock.*)

Step 1.—Through a fine needle inject into the cephalic part of the sac 3 centigrams novocaine or 2 centigrams stovaine, dissolved in ½ c.c. sterile 10 per cent. alcohol. Inject slowly, withdrawing the piston several times during the injection to insure thorough mixing of the analgesic with cerebrospinal fluid. The low specific gravity of the mixture prevents it affecting the higher centres of the cord while the child is inverted, and of course most of it escapes during the operation so subsequent danger is averted.

Step 2.—If the sac is not too thin dissect away all abraded and ulcerated areas and disinfect again. By transillumination note the position of nerve filaments and of portions of spinal cord so as to avoid them. Free the skin from the sac and retract the former.

Step 3.—Puncture the sac. Resect redundant sac if there is room between adherent nerve elements, otherwise let it collapse into the spinal cavity. With a continuous fine (oo to ooo) chromicized catgut suture fix the sac so that it [redacted]fold.

[redacted]Incise the edge of the dura where it blends with the inner surface

of the laminæ and strip it from the bony canal for the entire length of the defect. Suture the mobilized dura over the cord thus restoring the dural canal.

FIG. 936.—(*Babcock.*)
1. Skin; 2, muscle and aponeurosis; 3, bone flap; 4, sutured dura.

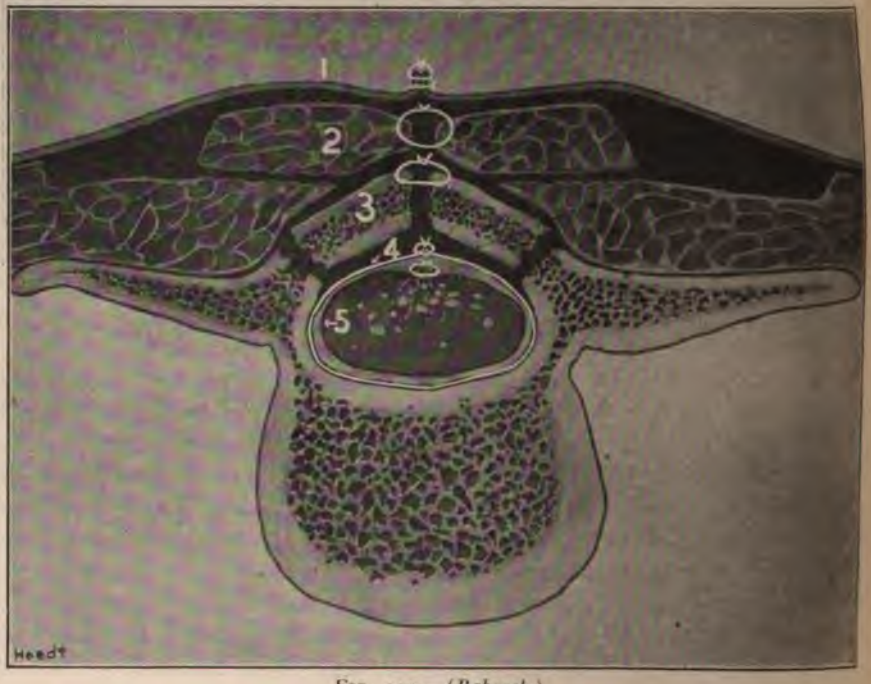


FIG. 937.—(*Babcock.*)
1. Skin everted and sutured; 2, musculo-aponeurosis flap united; 3, bone flaps united; 4, dura united; 5, reconstructed cavity of spinal arachnoid.

Step 5.—Freely expose the margins of the bony canal and divide the laminæ with bone forceps (Fig. 936). This forms a ribbon of bone and fibrous tissue on each side of the defect. Suture the two ribbons together and thus restore the bony canal (Fig. 937).

Step 6.—From the erector spinæ muscles on each side of the defect form two flaps of muscle and overlying aponeurosis, attached above and below. Suture these two flaps in the middle line. Close the skin wound with mattress sutures so that there is eversion and the thin skin is so approximated that leakage and necrosis is not likely to occur.

Some surgeons have recommended that the osseous defect be closed by means of a flap of bone obtained from the crest of the ilium and provided with a pedicle. This procedure must rarely be indicated.*

Operations to Immobilize the Spine in Pott's Disease.—Apart from hygienic measures and the treatment of abscesses, immobilization has been and still is the desideratum in the treatment of tuberculosis of the bodies of the vertebræ. As a substitute for mechanical supports and braces the following osteoplastic operations have been devised and carried out.

Hibbs' Operation.—Object: To produce fusion of the bones of the spine from a point two vertebræ above to a point two vertebræ below the diseased bones.

1. Make a vertical median incision sufficient to give ample access to the diseased vertebræ and to two healthy vertebræ above and also below the disease.

2. With *sharp* and blunt dissection separate the periosteum from the spinous processes and the laminæ on each side, carefully separating it and the interspinous and interlaminar ligaments from the upper and lower edges of the spinous processes and the laminæ. Continue the dissection outwards until the posterior surface of the transverse processes are bared. The periosteum and interspinous ligaments must be reflected to each side as a single flap continuous from the upper to the lower end of the wound. In the centre of the wound lie the spines and laminæ entirely bare of periosteum, their upper and lower edges being also bare. No tags of fibrous tissue must be present. During the whole of the dissection *no muscle should be seen;* if the muscular planes are penetrated the dissection has been faulty and bleeding will give annoyance.

3. With a chisel or gouge cut a thin slice of bone from the surface of the lower half of each lamina, the pedicle of this bone flap being on the base of the corresponding transverse process. Turn the bone flap downwards in such a manner that it bridges the interlaminar space vertically and its raw surface lies flatly in contact with the lamina of the next vertebra. Hibbs thinks the greatest value of this step is the production of a bony buttress preventing the interposition of fibrous tissue which might interfere with bone fusion.

4. With bone-cutting forceps divide the base of each spinous process throughout the upper three-fourths of its vertical diameter (the lowest vertebra is divided throughout its *lower* three-fourths). Fracture and turn downwards each spinous process (the last one is turned upwards) so that there results a vertical row of fragments of bone overlapping each other. Suture the periosteal and fascial flaps over the bones. Close the skin

thorough description of spina bifida and its operative treatment the reader is ildebrand's article in the "Archiv f. klin. Chirurgie." Bd. xlvi, Heft 1.

wound. If the operation has been properly performed there will be very little bleeding and no drain is required. Every detail of the work can be done with instruments, so that it is unnecessary and therefore objectionable, to put a finger in the wound. Apply dressings. Hibbs believes that the treatment of the spinous processes is the least important step in the operation.

6. Immobilize the spine in a jacket for one year.

Remarks.—While suitable for old neglected cases, the operation is particularly valuable in early disease. If psoas abscess is present, evacuate the tuberculous pus and close the puncture a day or two before attacking the spine.

Albee's Operation.—("Journ. A. M. A.," Sept. 9, 1911).

Step 1.—Make a median dorsal incision over the tips of the spinous processes from the last healthy vertebra above to the first below the affected bones.

Step 2.—Split longitudinally each process for about 1¼ inches into two portions with one-third of the process on the left and two-thirds on the right. Separate the soft structures between the processes parallel with the muscles. Produce a green-stick fracture at the base of the one-third portion of each of the processes. Temporarily pack the long gutter-shaped wound.

Step 3.—Make an incision over the side of the tibia and reflect the skin so as to expose the crest of the bone. (It is best not to have the skin incision directly over the segment of bone to be removed.) With a chisel or motor saw remove a prism-shaped piece of bone with the periosteum intact on two of its surfaces from the antero-internal aspect of the tibia. This piece of bone must be long enough to reach from the uppermost to the lowest of the split vertebræ; it should be about 1 inch wide and ½ inch thick.

Step 4.—Place the fragment of bone in the gutter prepared on the back, between the fragments of the split spinous processes. Suture the dense fascia over the tips of the spinous processes. Close the skin wound. Dress. Immobilize.

Step 5.—Close and dress the wound in the leg.

PART VI

CHAPTER LX

NERVES

NERVE SUTURE; NEURORRHAPHY

Nerve Suture.—When a nerve is divided the axis cylinders of the distal segment promptly degenerate and the medullary sheaths break up and disappear. The nuclei and protoplasm of the sheath of Schwann proliferate and form a new sheath ready for the reception of new axis cylinders, if such succeed in reaching the distal from the proximal segment.

In the proximal segment there is proliferation of the axis cylinders (neurones; neurites). If the divided ends of the nerve are kept in apposition and aseptic, they unite by first intention and the axis cylinders from the central end pass into the sheaths prepared in the peripheral end. Before the nerve can regain its function the axis cylinders must penetrate the whole length of the nerve to their peripheral end organs which they do under favorable circumstances, at the rate of about 1 to 2 mm. per day. In experiments on animals Van Lair found that when the divided ends were in contact, function returned in from 8 to 11 months. When they were 1 cm. apart recovery took 14 months; when 2 cm. apart 30 months, and when 4 cm. apart there was no recovery.

If the ends of the divided nerve are too far apart or if prompt union is prevented by infection, etc., the gap between the divided ends becomes filled with fibrous connective scar tissue; the divided end of the distal segment becomes covered with a comparatively thin and not prominent cap of scar tissue; the end of the proximal segment forms a bulb of varying size (neuroma) (Fig. 938). The bulb or neuroma consists of a tangle of new axis cylinders, proliferated Schwann cells and connective tissue; a structure identical with the familiar amputation neuroma. The axis cylinders have proliferated, have endeavored to reach the distal segment, have failed to pass through the interposed structures, have lost their way, many have turned back on themselves. If the hiatus is not too great and the fibrous tissue filling it is not too efficient a barrier, axis cylinders may in time and by devious routes gain the peripheral segment and recovery may ensue.

If the nerve is crushed instead of divided there is destruction of the nerve elements and complete physiological division with apparent anatomical continuity. Fig. 940. Degeneration, repair or failure of repair go on identically as in case of evident anatomical division. Partial section of a nerve either

by division or crushing leads to the same phenomena as in complete section but limited to the portion of the nerve trunk affected and in such lesions notches and lateral neuromata are found. Figs. 939, 940, 941.

In the above remarks it is assumed that the lesions have been sufficient to cause complete anatomical or physiological solution of continuity with consequent degeneration of the peripheral segment of the nerve. All degrees of injury are possible even so slight as to cause no peripheral degeneration and in such early recovery ensues under proper treatment. "A very great number of nerve injuries (more than 50 per cent.) are cured spontaneously without any intervention" (Treatment and Repair of Nerve Lesions, Mme., Athanassio-Benisty).

Two or three weeks must elapse after the injury before there can be any true symptom picture regarding the nature and extent of the lesion and many careful examinations may be necessary to determine its exact location and degree.

FIG. 938.

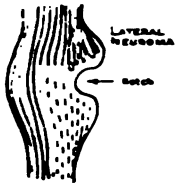


FIG. 939.

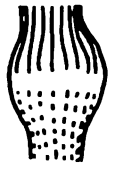


FIG. 940.

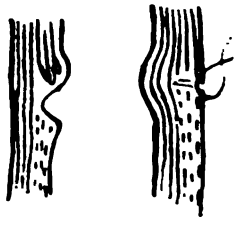


FIG. 941.

Different nerves react differently to injury. Mme. Athanassio-Benisty writes: "Clinical examinations will have to be made at frequent intervals in order to arrive at a conclusion with the least loss of time.

In complete paralysis of the musculo-spiral or of the external popliteal, if the clinical signs remain severe four or five months after injury, and if the nerve shows no sign of regeneration, it may be assumed that there is an indication to interfere and to examine the appearance of the anatomical lesion.

If the nerve is found to be divided or completely crushed, suture performed directly after resection generally gives the best results.

With regard to injuries of the ulnar, the fifth month is also the maximum period of time to be allowed before exploratory incision should be made, when signs of a severe lesion are persistent.

This nerve is slow to regenerate after suture or resection, and it is important not to allow too much time to elapse before operating.

The median and great sciatic regenerate unsatisfactorily, slowly, and in a variable manner. Spontaneous regeneration never takes place in less than eight to ten months after the wound, but when these nerves are divided, crushed, or severely injured, their regeneration is particularly protracted. Thus, when clinical examination reveals persistence of the signs of a severe lesion, the fourth month should not be allowed to elapse before interfering."

Remote results of operation for wounds of the sciatic and it's branches. (Auvray, Bull. et Mem. Soc. de Chir. de Paris, xlvi, p. 1121, 1920). From 19 out of 24 personal cases, it was possible to obtain information.

4 cases operated on for pain (liberation of nerve, removal foreign bodies) 2 completely recovered. 2 improved.

14 cases operated on for paralysis. In 9 the operation was 'liberation' of the nerve with only 2 cures and seven failures. In 5 cases there was end-to-end suture; of these there was 1 satisfactory result and 4 failures.

1 case operated on for 'reflex paralysis' with improvement. The same surgeon had good results in two-thirds of his cases of operations on the radial (musculo-spiral) nerve.

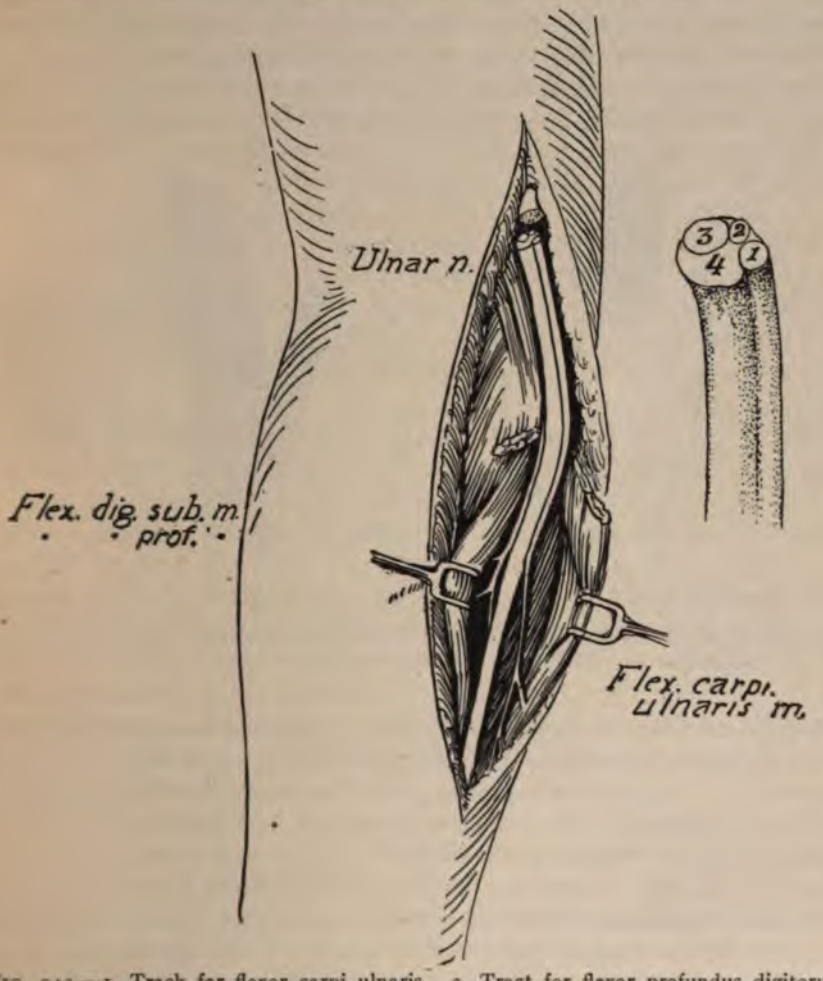


FIG. 942.—1. Track for flexor carpi ulnaris. 2. Tract for flexor profundus digitorum. 3. Tract for hypothenar eminence, interossei, third and fourth lumbricals, adductor pollicis and deep head of flexor brevis pollicis, 4. Sensory tract. (*Vulpius and Stoffel.*)

Vulpius, Stöffel and others have observed that bundles of nerve fibres destined for distribution to certain muscles or areas, occupy definite positions in the main trunk of the nerve. Pierre Marie with Meige and Gosset by means of electrical stimulation in the operation wound have proved the existence of this systematic intra-truncular distribution and determined the topography of

certain nerves. In uniting divided nerves by suture the great importance of avoiding all torsion must be evident, otherwise a bundle of nerve fibres normally belonging to one muscle may be sent to another (Fig. 942).

Restoration of function after suture for complete division is subject to much variation. (*a*) ***Muscle tone*** returns early; later muscular sensibility; (*b*) ***Cutaneous sensibility.*** Protopathic begins to return in from 6 weeks to 6 months and is complete in from 6 to 12 months. Epicritic sensibility begins to appear in about 6 months but is not complete for a very long time. (*c*) ***Motion.*** The return of motion depends to some extent on the distance of the nerve lesion from the muscles supplied. The muscles nearest the site of nerve suture regain power first. Motion may be expected to show itself in from 6 to 9 months but may not be at its maximum for 2 to 3 years. (*d*) Trophic power returns *pari passu* with general nerve recovery. (*e*) Tinel considers formication the

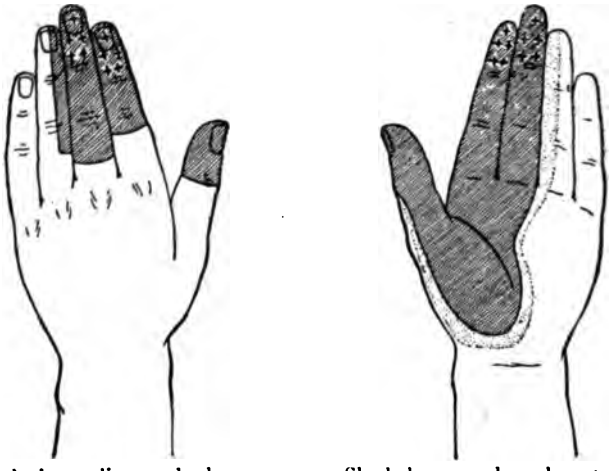


FIG. 943.—Paralysis median and ulnar nerves. Shaded areas show loss to pin-prick and cotton-wool. (*Manual Neuro-Surg., U. S. A.*)

most important sign of nerve regeneration. If pressure is made over the nerve trunk the patient experiences a tingling sensation in the area of its cutaneous distribution. Formication begins in 4 to 6 weeks and as the new fibrils grow down the degenerated nerve, their progress can be traced by the advancing zone in which the tingling is observed.

It has long been known but not properly appreciated, that prophylactic treatment of paralytic deformities is of very great importance. Stretching of paralyzed muscles must be prevented by proper posture, splints or apparatus. Nutrition of the muscles must be favored by massage, etc. In fact deformities must be prevented and the muscles kept in such condition that they can act as soon as nerve activating force can be supplied.

Primary Neurorrhaphy.—When a nerve of any importance has been divided it ought to be sutured at once. This presupposes the possibility of asepsis. In mobile war, the extent of the trauma, the long [illegible] before operation can be undertaken, the rush of life-savi[illegible] and [illegible] the evacu[illegible] hospitals all tend to make primary

activity as in trench fighting the primary suture is often feasible and becomes a great conservative agency. In civil life primary neurorrhaphy should be the rule. If the wound in the nerve is much contused it must be trimmed with a sharp knife (the blade of a safety razor) as the contused tissue will die and form a barrier against regeneration. In suturing use very fine silk or linen, preferably waxed, threaded on fine cambric needles. Fine plain catgut may be employed.

Direct Suture.—Through the sheath of the nerve introduce three or four symmetrical stitches and gently approximate the cut ends of the nerve. It is important to completely close the epineurium to prevent escape of growing nerve fibrils. Be careful not to rotate the nerve when the sutures are being tied, lest the intra-truncular arrangement of nerve bundles be disturbed. One stay suture through the whole thickness of the nerve may be of value. Never handle the nerve ends with forceps. Do not have any tension on the sutures, this is fatal to success. If the nerve is only partially divided suture of the divided portion is easy and should be done.

Indirect Suture.—Fibrous tissue around the divided nerve is united by sutures and helps to hold the ends in position. If it is difficult to bring the divided ends of the nerve together flexion of the limb may overcome the difficulty and must be kept up until union is advanced. (See remarks by Sir Robert Jones, page 787.) Implantation of a segment of nerve to bridge a gap may be necessary.

Secondary Neurorrhaphy.—A nerve has suffered anatomical or physiological division partial or complete. Sufficient time has passed to permit the assumption that either no restoration of continuity has been attained or that all the possible recovery of function has already returned and is insufficient. An exploratory operation is necessary.

Step 1.—If possible avoid the use of a tourniquet. Expose the nerve above and follow it down to the site of injury. If necessary expose it also below and follow it up. It is usually wrong to expose the mass of scar tissue directly and endeavor to find the nerve in it.

I. The want of conductivity is apparently due to pressure by a fragment of bone, or a mass of scar tissue. Free the nerve (neurolysis) and take precautions to avoid recurrence.

II. It is suspected that a mass of scar tissue inside the nerve is at fault. Split the nerve longitudinally and remove the noxious material. When freeing the nerve be careful not to divide branches.

III. There is a very small amount of interstitial scar tissue. Injection of salt solution into the nerve may open up new channels for nerve growth.

IV. There is a distinct neuroma with apparent anatomical continuity (Fig. 940). Split the neuroma and note that the axis cylinders fail to pass through. Treat exactly as if there was evident anatomical division.

V. There is evident anatomical division, the two ends of the nerve being separated by a greater or less amount of scar tissue.

Dissect the scar from its surroundings but *not* yet from its nerve attachment. [redacted]ping the *scar tissue* with forceps make gentle traction *through it* on the nerve [redacted]ee it better and obtain some lengthening. With a sharp knife *partially*

cut through the scar tissue transversely. Leaving some of the scar tissue intact provides a useful handle and guide to aid in accurate suturing. Cut off thin, transverse slices from the upper and lower segments of the divided scar until so much of the neuroma has been removed that healthy nerve fibrils are exposed in the upper segment and good nerve channels in the lower. Suture with fine silk, linen or plain catgut, using fine non-cutting needles and including as little of the nerve in the suture as possible. Avoid axial rotation of the nerve.

An exhaustive experimental investigation of material for nerve suture (Sargent and Greenfield, Brit. Med. Jour., Sept. 27, 1919) justifies the following conclusions:

(1) Plain thread or silk sutures cause no irritation, but are relatively unabsorbable.

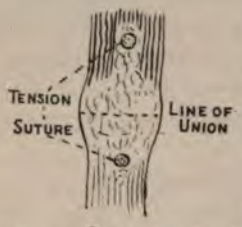


FIG. 944.—(*After Sargent and Greenfield.*)

(2) 'Plain sterilized' or 'plain iodized gut' are rapidly absorbed, but have low tensile strength and are slightly irritating.

(3) 'Japanese silkworm gut' has great tensile strength and in rate of absorbability and reaction which it causes, holds a place midway between groups 1 and 2.

(4) Chemical antiseptics should be avoided in all suture material.

(5) The disadvantages of any suture material are exaggerated when passed through the whole thickness of a nerve in the form of a tension suture, as this tends to produce an intraneural neuroma above and below, thus forming a hindrance to regeneration (Fig. 944).

Similarly excise the rest of the scar tissue and complete the suturing. Exact hemostasis is important. Bleeding from the nerve may be controlled by gentle pressure with gauze wrung out of warm water or with a small fragment of muscle.

VI. There is a gap between the two ends of the nerve, which cannot be closed sufficiently to permit of direct end-to-end suture. Transplantation may be used. The 'cable' transplant is the best, as by this means a slender unimportant nerve may be employed as the implant.

Expose and excise, with gentleness, a long segment of such a nerve as the Lesser Internal Cutaneous or the Superficial Radial in the arm or the External Cutaneous or the Short Saphenous in the leg.

Expose and prepare the ends of the nerve it is desired to unite.

With a sharp knife cut the implant into segments of length sufficient to fill the gap. With a fine suture perforating the segments near their ends unite them into a cable. The suture must not compress the nerves.

Suture the ends of the cable to the proximal and distal stumps of the nerve to be repaired.

VII. The nerve is only partly divided, there is a unilateral notch and neuroma. Excise the neuroma and scar tissue exactly as described above, but most jealously preserve the intact portion of the nerve.

The advisableness of surrounding the line of suture with some material such as Cargile membrane, fat, fascia, formalinized artery, etc., in the hope of avoiding adhesions, is a matter of much discussion. On the whole the best method for avoiding adhesions, is to place the repaired nerve in the sulcus between two muscles and to be very exact in securing hemostasis.

No apology is required for quoting at length, opinions expressed by Sir

Robert Jones in his address before the American College of Surgeons (Brit. Med. Jour., Nov. 8, 1919).

"Experience taught us that it was better to explore earlier and more frequently than we did at the beginning of the war."

"It is found that if a nerve is simply concussed or compressed, and has undergone Wallerian degeneration, it will early show signs of recovery. In cases which do not spontaneously recover in a month or two, it is usually a mistake to await regeneration of the nerve, and an exploratory operation should be undertaken. Inspection of the exposed nerve at the time of operation and its faradic excitability should be regarded as a part of diagnosis. It is essential in such cases that the surgeon should be experienced in nerve surgery, and be prepared to close the wound without interfering with the nerve if it has an intact sheath, and gives a faradic response when tested with a weak current. It is probable that no interval between wound and operation is too long to preclude possible recovery after suture. The state of the muscles, tendons, and joints is the important factor.

"It has been found in practice that end-to-end suture can be attained in the great majority of cases by posturing the joints and by transposing nerves. An inch and a half can be gained by transposing the musculo-spiral to the inner side of the humerus, and several inches by transposing the ulnar to the front of the elbow. In the rare instances where the nerve could not be brought together we found this could be accomplished by a two-stage operation. Silk was tied around the bulbs, and they were brought together as nearly as possible, extra length being secured by posturing the limb. The wound was then closed and gradual traction applied to the nerve through the limb for some weeks. At the second operation it was found that the ends could usually be brought together. It is needless to emphasize the importance of approaching the nerve through normal tissue above and below the lesion were it not that even yet surgeons may be found making the exploration through scar tissue. Nothing is to be gained from surrounding the suture line with vein or Cargile membrane or fat introduced from without. If the nerve has to be protected from scar tissue, a living muscular flap is indicated, but, whenever possible, the scar tissue should be freely excised. The Medical Research Committee, whose report is not yet published, has carefully investigated a large number of cases operated upon. In the case of nerve grafting they have not met with one case of complete recovery and but very few partial recoveries. Most cases have ended in failure. Bridging by catgut, vein, alcoholized nerve, and other foreign material has consistently failed. The turning down of flaps of nerve, and nerve crossing or anastomosis—that is, implanting the distal end of the divided nerve into a healthy one—invariably fails. The conclusion come to is that end-to-end suture by a one, or, if necessary, a two-stage operation, is the method to be adopted in every case.

"In cases of irreparable damage to the musculo-spiral or posterior interosseous, tendon transplantation properly performed has proved an unqualified success. It must be associated with a good technique, and be followed by careful re-education. The operation I suggested in pre-war days with certain modifications I still recommend, but I advocate a more frequent use of the

pronator radii teres. The flexor carpi radialis and the flexor carpi ulnaris can be transplanted into the paralyzed extensors of the thumb and fingers, and the pronator radii teres may be affixed to the radial extensors. In transplanting tendons it is important to pay careful attention to the correct tension, and the hand and fingers should be kept well dorsiflexed when the attachments are being made, and the transplanted tendon must run a straight course from its origin to its new insertion. Attention to these points will make the difference between success and failure. If the operation is a real success, the fingers and thumb can be easily fully extended. Tendon transplantation with the object of merely dorsiflexing the wrist should be discouraged, and tendon fixation with the object of permanently fixing the wrist in dorsiflexion should be reserved for those cases where transplantation has been a failure and where the extensor muscles and tendons have been destroyed."

"The prognosis as regards functional utility after nerve suture depends very largely upon which particular nerve has been injured. Thus the musculo-spiral usually makes a good recovery, whilst the ulnar, as regards the intrinsic muscles of the hand, does badly. Another factor of importance in prognosis is the occupation of the patient. A man with an ulnar nerve lesion will usually recover both sensation and muscular control quite well enough for most trades, but he will not recover control of the finer movements of the hand—such as are needed for piano playing.

"After the musculo-spiral, in order of good recoveries, we must place the sciatic. The results of suture here are surprisingly good. A large number of our cases were examined two or three years after suture. Some of these men could jump, climb ladders, and run, and many have returned to their pre-war employment.

"The brachial plexus often makes a good recovery, especially the upper part. Plexus lesions should be watched for a long time, six to nine months or more, and not operated on for exploratory purposes as are the nerves themselves, because they frequently make excellent progress, and a generalized paresis may later be limited to one cord, or nerve.

"Median injuries do fairly well, the thumb intrinsics even recovering in some cases, whilst it is usual for the wrist flexors and considerable sensation to recover. Sensation, however, is usually lost, or very slowly or rarely recovered from, over the terminal phalanx of the index-fingers.

"The ulnar recoveries are good as regards wrist and finger flexors, and even its sensory disturbance clears up well. As has been stated, good recovery of the interossei is very rare. They may and do recover their faradic excitability more often than voluntary power.

"Combined lesions of the median and ulnar, particularly if complicated by ligation of the artery, do very badly. There is usually the stiff, rigid, board-like hand with joint changes to still further hinder the chance of good function. This is, indeed, the important obstacle.

"The after-treatment of cases of peripheral nerve injury has not undergone much change. The relaxation of muscles is essential, and it is also necessary that the relaxed position of the nerve should not be too early dispensed with, otherwise the recently regenerated axis cylinders will be ruptured. Interrupted

galvanic stimulation, massage, heat and re-education are indispensable desiderata."

Direct Implantation of a Nerve into Muscle.—Attempts to restore function to a paralyzed muscle have usually been made by anastomosing a healthy motor nerve to the nerve trunk which supplied the muscle. Heineke (Zent. für Chir., 1914, No. 11) conceived the idea that by implanting the sound nerve into the muscle, the axis cylinders might either distribute themselves to the individual muscle fibres by growing into the preexisting nerve paths or might reach the muscle fibres directly and form new nerve endings.

Heineke and his assistants produced paralysis of certain muscles in rabbits by exposing the two branches of the sciatic nerve (tibial and peroneal) and excising 1–2 cm. of the tibial nerve. The peroneal nerve was then exposed downwards and divided below the head of the fibula. The central end of the peroneal nerve was now pulled through a tunnel bored in the gastrocnemius and fixed there. After 14 days the gastrocnemius responded slightly to faradic and galvanic stimulation of the peroneal nerve in the thigh. After four weeks the reaction was powerful while "after eight weeks the power and extent of the contractions could not be distinguished from the normal and were not confined to the muscle in which the nerve was implanted but the neighboring muscles of the flexor group took part in the contractions. The muscles which were at first atrophied and yellow regained their normal color and consistence." A muscle enervated for 21 days can recover after direct implantation of a healthy nerve.

An extraordinary case of secondary nerve suture of the facial nerve is reported by Emmet Rixford. Eight weeks after an injury the facial nerve was identified as it left the stylomastoid foramen and was found to be divided 1 cm. below this point. The distal segment was found with great difficulty by first exposing the two principal branches in the parotid and tracing them back. The gap between the segments was about 1 cm. The proximal segment after vivification was so short that stitches could not be introduced. Rixford cut away enough of the mastoid process and the external wall of the aqueduct of Fallopius so that the nerve could be mobilized and the two segments united by sutures. The result was entirely good. In repose the two sides of the face looked alike and the patient could close the eye on the affected side independently of the other with an expressive wink. ("Trans. Am. Surg. Assoc.," xxii.)

Suture of Recurrent Laryngeal Nerve.—Shelton Horsley ("Annals of Surg.," li, 524) reports a case in which the left recurrent laryngeal nerve was divided by a bullet at a point just before the nerve entered the larynx. The voice was hoarse and weak. Respiration was impeded. The left vocal cord was paralyzed and the larynx above the glottis was congested. Horsley operated as follows: Make an incision along the anterior border of the left sterno-mastoid. The middle of this cut is opposite the inferior limit of the larynx. Retract the sterno-mastoid and with it the carotid and internal jugular outwards. Expose the left lobe of the thyroid and retract it to the right along with the trachea and larynx. Look for the nerve in the groove between the trachea and œsophagus. In Horsley's case the wounded part of the nerve was surrounded by a mass of scar tissue. About 8 mm. of involved nerve was excised and the

divided ends united by a fine catgut suture. Six days after operation there was no improvement in the symptoms. Three months later the movements of the glottis were almost normal though the left vocal cord seemed a little weak. The voice was no longer hoarse but had not regained its full volume. Shepherd has successfully sutured the recurrent laryngeal nerve after it had been accidentally divided during a strumectomy.

NERVE ANASTOMOSIS

I. *Nerve Anastomosis for Facial Paralysis.*—The first operation of this kind was performed by Ballance and Purves in 1895. Faure operated in 1898, and in 1900 Robert Kennedy in a case of severe facial spasm divided the facial nerve, uniting the proximal extremity of its distal portion to the partially divided spinal accessory nerve. The result was perfect.

Harvey Cushing ("Annals of Surgery," May, 1903) reports a case in which the facial nerve was destroyed near the stylo-mastoid foramen. After the original wound (pistol wound) was thoroughly healed, the following operation was performed:

1. Incision along anterior border sterno-mastoid.

2. Exposure spinal accessory nerve at point of entry into deep surface of sterno-mastoid, about two inches below the tip of the mastoid.

Exposure distal segment of facial nerve by incising the posterior border of the parotid gland in a line parallel to and directly under the original skin incision. If this cut be made carefully, one of the main branches of the nerve is certain to be encountered and can be followed back by blunt dissection *without* (Fig. 945) isolating the nerve itself.

3. Square division of facial nerve close to the scar tissue existing at point of original injury.

4. Division spinal accessory nerve at point of entry into the muscle.

5. Approximation of the two nerves, without tension, over the posterior belly of the digastric muscle. Suture.

6. Closure of wound.

Improvement was noted after an extraordinarily short time. The ultimate result was most gratifying.

Murphy insists on the importance of imbedding the point of nerve union inside a muscle belly (*e.g.*, sterno-hyoid). In one case he saw the point of union imbedded and compressed into uselessness by scar tissue. After freeing the nerve from scar tissue and imbedding it in muscle a good result was obtained.

Instead of using the spinal accessory, the hypoglossal nerve has been utilized to supply nerve stimuli to the facial. This was first done by Ballance and Stewart, later by Frazier. The glossopharyngeal nerve has also been similarly used. The various operations for facial palsy may be systematized as follows:

Anatomy.—The facial nerve emerges through the stylo-mastoid foramen where it is deeply seated; from here it runs "downwards, outwards and a little forwards to turn or wind round the st[illegible]cess, after this its course is almost horizontally f[illegible]til it c[illegible]sterior auricular artery and immediately plur[illegible] parot[illegible]he horizontal portion.

e nerve is situated at the level of the tip of the lobule of the ear, *i.e.*, about ch below the lower border of the zygomatic arch."

he Spinal Accessory Nerve.—The external, spinal or surgical portion of nerve emerges from the skull through the jugular foramen; from here it

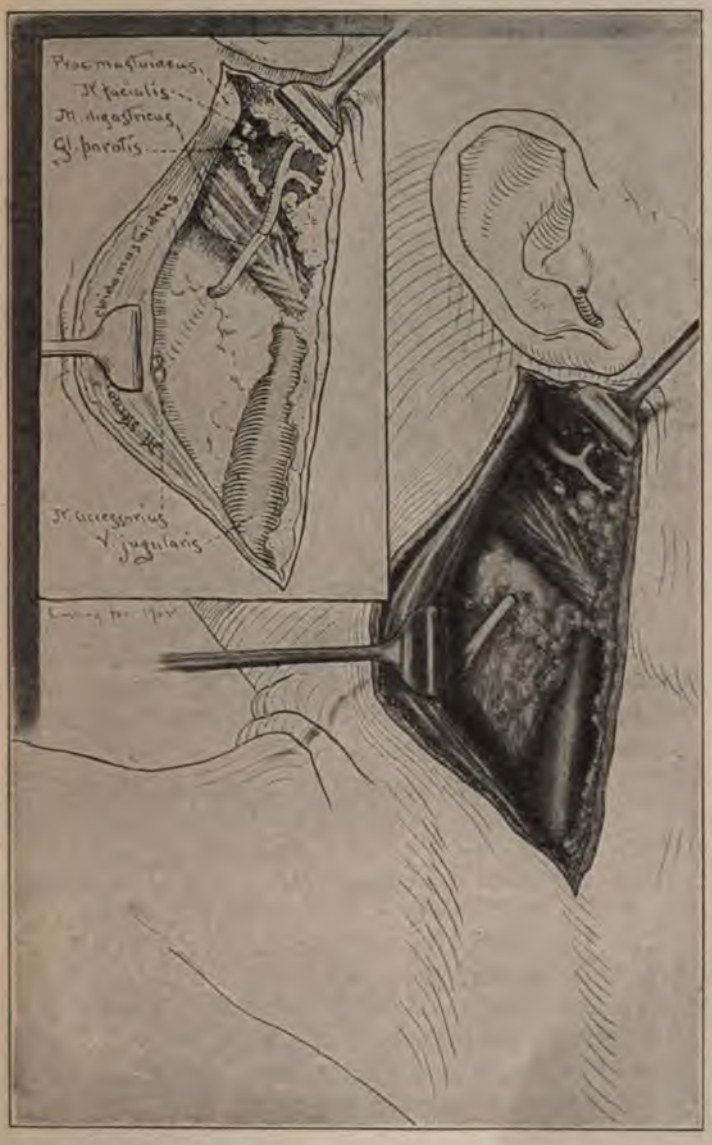


FIG. 945.—Nerve anastomosis. (*Cushing, Annals of Surg.*)

es downwards, outwards and a little backwards in front of (rarely behind) internal jugular vein between that vein and the occipital artery which es it perpendicularly. The nerve now lies exactly between the *transverse ss of the atlas* and the posterior border of the digastric. Below this point

the nerve passes behind the posterior border of the parotid to enter the deep surface of the sterno-mastoid 2 inches below the apex of the mastoid process.

The Hypoglossal Nerve.—The hypoglossal nerve leaves the skull through the anterior condylar foramen and lies on the inner side of the deep cervical vessels. As it descends, the nerve comes forward between the internal carotid artery and jugular veins to the lower border of the digastric muscle where it curves forwards round the origin of the occipital artery, the sterno-mastoid branch of which turns downwards over the nerve. From this point the nerve runs forwards above the hyoid bone, passes under the tendon of the digastric, the lower end of the stylo-hyoid and the mylo-hyoid muscles, and crosses the external carotid and lingual arteries.

Spino-facial Anastomosis.—Step 1.—Incision along the anterior border of the sterno-mastoid, beginning above in the groove between the external ear and the mastoid at the level of the tragus and ending at a point about 5 inches lower.

Step 2.—Retract the ear forwards. Divide the fibrous tissues covering the mastoid so as to gain access to its anterior border. Expose the anterior border of the sterno-mastoid.

Step 3.—With blunt dissection penetrate between the parotid, the anterior border of the mastoid. Move the dissecting instrument horizontally and *not* vertically, to avoid injuring the nerve. The nerve should be found at a depth of a little less than ½ inch from the surface of the mastoid at the junction of its lower and middle thirds (Marion). Isolate the nerve and divide it as far back as possible.

Step 3.—Open the sheath of the sterno-mastoid longitudinally. Demonstrate the transverse process of the atlas about ½ inch below the mastoid, and expose it clearly to sight by bluntly dividing the fibrous tissues covering it. Demonstrate the posterior belly of the digastric in front of the atlas. The spinal accessory nerve lies between the transverse process of the atlas behind and the digastric in front. Isolate the nerve.

Step 4.—Divide the nerve as its entrance into the sterno-mastoid, and make an end-to-end anastomosis between its proximal segment and the distal segment of the facial.

Step 5.—Bury the line of nerve suture in the belly of the digastric muscle after incising the muscle for this purpose.

Step 6.—Close the wound with buried and superficial sutures.

Hypoglosso-facial Anastomosis.—*Step* 1.—From a point on the level of the tragus, in the groove between the external ear and the mastoid, make an incision downwards along the anterior border of the sterno-mastoid to a point a trifle below the angle of the jaw; from this low point cut forwards horizontally on the level of the hyoid bone, for about 1 inch.

Step 2.—Expose and divide the facial nerve as in the spino-facial anastomosis.

Step 3.—In the lower part of the wound open the sheath of the sterno-mastoid anteriorly, retract the muscle backwards, divide the deep layer of the sheath of the mastoid at the level of the greater horn of the hyoid. The hypoglossal nerve is to be sought either posteriorly where it crosses the external

arotid (Fig. 946) or anteriorly between the greater horn of the hyoid and the posterior belly of the digastric.

Step 4.—Free the nerve very gently from its surroundings. Divide the nerve so far forwards that enough isolated nerve trunk is left to be turned upwards and forwards and united without tension to the distal segment of the divided facial nerve. Complete the anastomosis.

Steps 5 *and* 6.—As in spino-facial anastomosis.

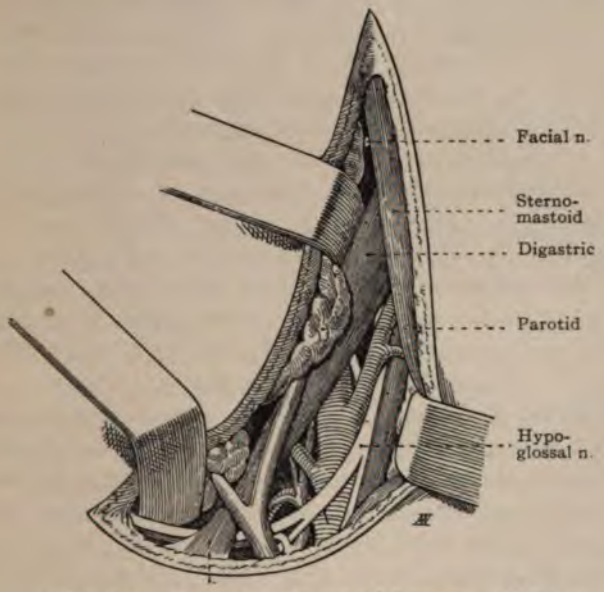


FIG. 946.—Exposure of hypoglossal nerve. (*Marion.*)

Indications for Operation for Facial Palsy.—1. Where it is known that he facial nerve is completely divided, immediately unite its divided ends possible; if this is impossible perform spino-facial or hypoglosso-facial anastomosis as soon as possible.

2. When there is reasonable doubt as to the permanency and completeness f the lesion, delay is justifiable. If there is no sign of recovery in six months, perate (Frazier).

3. In old cases test the facial muscles, if they are completely atrophied and o longer respond to the faradic current, probably operation will do no good. f the muscles respond to faradic stimulation operation is proper.

4. Facial palsy from "cold." This is probably an infective neuritis (Spiller). he prognosis is usually good without operation. If, after four to six months, he facial muscles are still almost completely paralyzed and reaction of degeneration is pronounced, Spil er would recommend anastomosis. The same rules pply to facial paralysis from middle ear disease.

C. E. Dennis (Brit. Med. Jour., Sept. 21, 1918) recommends highly a plint devised by Miss Jennings. If recovery from injury to the facial nerve

is going to take place it is as important to prevent overstretching of the paralyzed facial muscles, as of the foot muscles in anterior poliomyelitis. The splint consists of malleable German silver wire bent so as to hook into the corner of the mouth and over the ear of the affected side like the ear-piece of spectacle frames (Fig. 947).

Choice of Operation.—1. In palsy from division of the facial nerve immediate reunion is always desirable, but not often possible.

2. Spino-facial anastomosis is somewhat more easily performed than is the hypoglosso-facial operation, and the muscles paralyzed by the nerve section are less important. The spinal-accessory nerve, however, is dominated by the centres for associated movements of the shoulder, hence after operation there are liable to be movements of the facial muscles every time the patient raises his shoulder. Mr. Ballance has given up spino-facial anastomosis on account of the difficulty of securing dissociation.

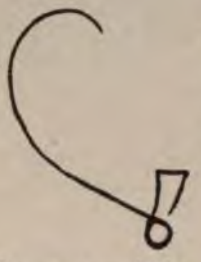


FIG. 947.—(*Miss Jenning's splint*).

3. Hypoglosso-facial anastomosis is not much more difficult than spino-facial, the muscles supplied are not of prime importance. The hypoglossal cortical centre is functionally more allied to the facial centre than is that of the spinal accessory.

Spiller writes: "In employing the hypoglossal as the nerve for anastomosis with the facial it is possible that emotional movements may be restored, and such seems to have been the result in a case observed by Köster and Bernhardt, in which the corner of the mouth on the affected side was moved during laughter."

Treatment of Facial Paralysis by Muscle Transplantation.—A. Jianu ("Deutsche Zeitsch. für Chir.," cii, p. 577. Ref. "Journal de Chir.," Feb., 1910) has operated by taking a flap from the sterno-mastoid muscle (pedicle above) and suturing it to the angle of the mouth. The result was satisfactory. Jonnesco, following Jianu's principle, exposed the masseter by a curved incision following the edge of the inferior maxilla (both the ascending and horizontal rami); split the masseter in the direction of its fibres; separated the anterior portion of the muscle from its insertion into the jaw, and so formed a muscular flap attached to the zygoma. This flap he sutured to the angle of the mouth. The result was correction of the deviation of the mouth; prevention of the escape of saliva; ability voluntarily to move the angle of the mouth.

The operation does not pretend to remedy the paralysis of the orbicularis muscle and must be of very limited value. Cuneo remarks that Jianu's operation should be reserved, in cases of total facial paralysis, to those in which nerve anastomosis has failed, and that when performed it should be supplemented by some operation on the eyelids, such as angular tarsorrhaphy.

Lexer (Eden, Beitr. z. klin. Chir., lxxiii, 123) has used a slip of masseter to support the mouth. His incision penetrates the skin and subcutaneous tissues in the naso-labial fold. From this cut he burrows back and down until the parotid is reached. The parotid is now retracted bluntly upwards and forwards to expose the insertion of the masseter from the anterior margin of which a flap 1 cm. wide, with pedicle above, is detached and sutured to the

tissues near the angle of the mouth. If there is paralysis of the eyelids a similar flap may be obtained from the temporal muscle and sutured to the external angle of the eye. The primary incision is vertical and made inside the temporal hair line; a small secondary incision close to the eye is necessary to permit suturing.

George Fenwick (Brit. Med. Jour., Nov. 29, 1919) operates as follows:

Preliminary to anesthesia inspect and compare the two sides of the face and mark on the skin (*a*) the lower half of the naso-labial furrow. (*b*) The position of the dimple in the center of the cheek which becomes evident when laughing. (*c*) The direction of one of the lines of crowsfoot below the external canthus.

Step 1.—Make an incision in the hair line from the Zygoma upwards and backwards to the top of the temporal fossa. The incision is parallel to the fibres of the temporal muscle. Undermine the skin to expose the fascia.

Step 2.—By parallel incisions along the direction of the fibres form a flap, with pedicle below, consisting of the whole thickness of the temporal muscle and its fascial covering. This flap should be as thick as a man's thumb. Immediately anterior to this make a similar but narrower flap. Detach both flaps from the underlying bone.

Step 3.—Make a small incision along the crowsfoot mark below the external canthus. Make a subcutaneous tunnel from here to the temporal wound. Pull the smaller muscle flap through the tunnel and suture its free end to the orbicularis palpebrarum. Of course the muscle flap should be fairly taut.

Similarly incise the skin in the lower part of the naso-labial groove and make a tunnel under the skin from the temporal wound to the angle of the mouth. Pull the larger muscular flap through the tunnel and suture its free end to the superficial fascia in the cheek wound and to the orbicularis oris below and slightly mesial to the angle of the mouth.

Step 4.—Suture the wound in the temporal muscle. Close the skin wounds.

After Treatment.—Begin massage and Faradism early. Have the patient practice, before a mirror, using the temporal slips of muscle in their new function.

II. DUCHENNE-ERB PARALYSIS—OBSTETRICAL PALSY

Paralyses of certain groups of muscles in the upper extremity may be recognized soon after birth. The origin of these paralyses is disputed. Until recently they were ascribed exclusively to tearing, stretching or compression of the brachial plexus during birth (Duchenne) or to trauma received later in life. The part of the plexus affected is believed to be at that point where the anterior primary divisions of the fifth and sixth cervical nerve roots unite. The motor fibres in these two nerve roots supply the deltoid; supraspinatus and infraspinatus; biceps; brachialis anticus; supinator longus and brevis, and the teres minor. Thus in a typical case of Duchenne-Erb paralysis the arm cannot be abducted at the shoulder, flexion of the elbow is impossible, the forearm is in a position of pronation, the whole arm is rotated outwards to such an extent that the palm of the hand may be directed outwards.

Wilfred Harris and V. W. Low ("Brit. Med. Journ.," Oct. 24, 1903) believe that Markoe's case ("Annals of Surg.," 1885, ii, 185) of division of the fifth

cervical root proves that the deltoid, spinati, biceps, and brachialis anticus derive their whole motor supply from this source, while the supinator longus is, at least in part, indebted to it for its motor impulses.

Turner Thomas ("Annals of Surg.," Feb., 1914) disputes these views vigorously. "The fact that in most cases there is practically no disturbance of sensation in the affected limb, although the roots of the brachial plexus are all mixed nerves, has not been satisfactorily explained." He believes that the great majority of cases of obstetrical paralysis of the upper limb are due to pressure on the front of the shoulder during birth, causing a bending down of the acromion process and specially a posterior subluxation of the head of the humerus. The bending of the acromion interferes with reduction. The fact that when this subluxation cannot be recognized after birth, spontaneous reduction being assumed to have occurred, complete recovery ensues under any or no treatment, also the fact that late correction of the persistent subluxation leads to improvement, support his views.

The presence of extensive adhesions about the plexus, as demonstrated at operation, renders doubtful the presence of ruptured nerve roots occasionally described, because of the great difficulty in dissecting accurately these delicate and interweaving structures under the unfavorable local conditions. Turner Thomas believes the adhesions are due to a spread upwards, no great distance, of the reparative inflammation at the injured shoulder joint. Lange, at operation, in one case found the cause of the paralysis to be the imbedding of the branches of the plexus in thick connective tissue in the axilla, and found also a diminution and deformation of the head of the humerus.

Immediately after birth reduction of the subluxation will probably be easy; after some months it is difficult because of anatomic changes. Thomas states, "the first indication at any stage is to reduce, the next to obtain the best possible motion at the shoulder joint." If the surgeon believes injury to the brachial plexus is primarily at fault (the author is strongly inclined to consider that Turner Thomas is correct in denying this), then when a case presenting the symptoms enumerated shows no improvement after two or more months of treatment by electricity, massage, etc., but, on the contrary, the electrical reactions of degeneration begin to appear, then operative treatment becomes proper. There are two methods by which improvement may be attained—one by nerve anastomosis, the other by muscle transplantation or transference.

(A) **Direct Method.**—*Robert Kennedy's Operation.*—("Brit. Med. Jour.," Feb. 7, 1903). Place the patient on his back, with a pan under the shoulders to permit of the head being well thrown back. Incline the head and face to the opposite side.

Step 1.—From the junction of the middle and lower thirds of the outer margin of the sterno-mastoid make an incision outwards and downwards to the junction of the outer and middle thirds of the clavicle. Divide the deep fascia between the sterno-mastoid and trapezius. Expose the omo-hyoid below the lower edge of the wound. Above the omo-hyoid expose the scalenus anticus muscle and demonstrate the nerve-trunks emerging from under it. Trace the two upper nerve-trunks outwards to their junction.

Step 2.—Having found the junction of the fifth and sixth nerves, recog-

he various branches and free them from adhesions (Fig. 948). Free ain trunks from the adhesions which seem to be always present.

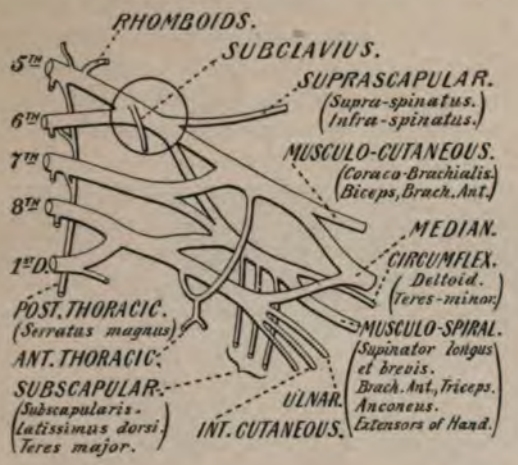


FIG. 948.—Duchenne-Erb paralysis.

he accompanying illustrations (Fig. 949, 950) taken from A. S. Taylor's le on "Brachial Birth Palsy" ("Journ. A. M. A.," Jan. 12, 1907) illustrate the anatomy of the brachial plexus.

FIG. 949.—(*Taylor.*)

Scalenus anticus. B. Phrenic n. C. Int. jugular. D. Transversalis colli a. E. Seventh root. o-hyoid. G. Fifth root. H. Scalenus medius. I. Sixth root. K. Suprascapular n. L. Ext. oracic n. M. Clavicle. N. Nerve to subclavius.

tep 3.—Note the condition of the isolated nerve. Kennedy has always d it to be in a hopelessly cicatricial condition. If the whole nerve seems

to be composed of scar tissue, divide the fifth and sixth above the diseased area. The cut surface ought to show a healthy appearance; if not, slice off more of the nerve until healthy tissue is reached. Pull the diseased area inwards and put on the stretch the three peripheral divisions of the nerve, viz., the supra-scapular nerve, the branch to the outer and that to the posterior cord of the plexus. Divide these three branches at points beyond the disease, the section being made through healthy nerve.

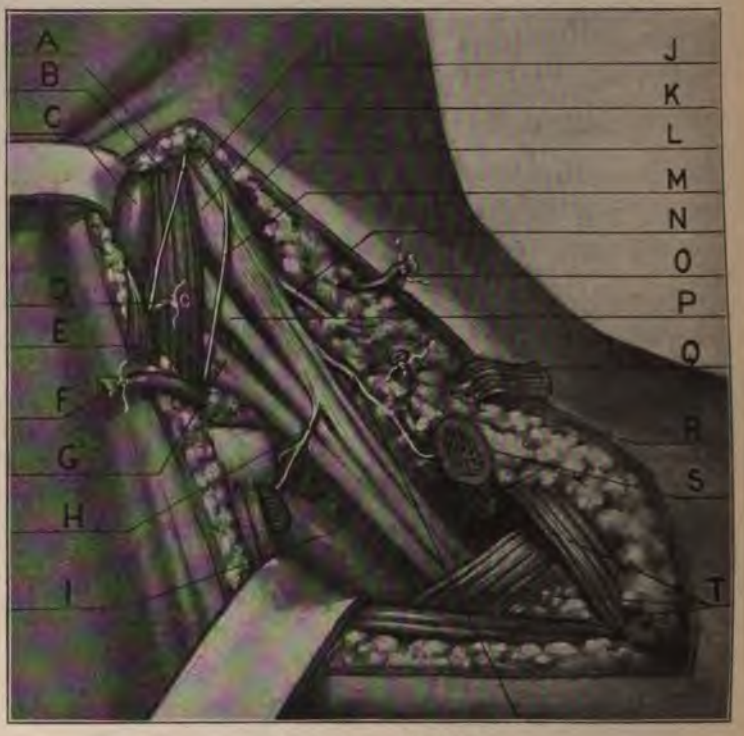


Fig. 950.—(*Taylor.*)

A. Phrenic n. B. Scalenus ant. C. Int. jugular. D,O. Transversalis colli a. E. Omo-hyoid. F. Suprascapular a. G. Eighth cervical and dorsal root. H. Muscular branch. I. Subclavian v. J. First root. K. Sixth root. L. Scalenus medius. M. Nerve to subclavius. N. Suprascapular n. S. Clavicle. subclavius. T. Pect. major. U. Ant. thoracic n.

Step 4.—Suture the three peripheral stumps to the two proximal stumps of nerve by means of fine chromicized catgut threads. Before approximating the divided nerve ends and tying the sutures, push the shoulder upwards and incline the head to the side being operated upon. This relieves tension, and permits of approximation. Cover the line of nerve suture with muscle, fascia or some material like Cargile's membrane.

Step 5.—Close the external wound. Apply dressings. With plaster-of-Paris or a suitable apparatus, keep the shoulder elevated and the head inclined to the side on which operation has been performed, and, above all, prevent motion of the head on the shoulders. When the lesion is more extensive, especially when it lies beneath the clavicle, continue the skin incision downwards between the pectoralis major and deltoid. Separate these muscles

Divide the clavicle in the same line, also the sub-clavius and omo-hyoid muscles and supra-scapular vessels. Pull the outer fragment of the clavicle and the shoulder outwards exposing the entire plexus to the upper margin of the pectoralis minor, which may also be divided if necessary. When the nerve suture is completed reunite the divided muscles and bone.

After two weeks the fixed dressings may be discarded. Kennedy does not advise any special after-treatment, believing that the nervous impulses, which can now reach the muscles, will lead to their satisfactory development. Most surgeons will undoubtedly endeavor to assist recovery by the use of electrical stimulation and massage.

Harris and Low think that Kennedy relies too much on the physical appearance of the nerves when exposed, and as a consequence may be led to excise too much. Thus, if the deltoid, spinati, biceps, and brachialis anticus muscles (and perhaps also the supinator longus) are paralyzed, and if Markoe's observation be remembered, then after exposing the nerves it would be wise separately to stimulate faradically the fifth and sixth nerves. If stimulation of the fifth fails to gain response while stimulation of the sixth does, then these observers advise that the fifth nerve be followed upwards, be divided well above the junction, and the proximal end of its peripheral portion be anastomosed to a split in the side of the sixth nerve. Part of this advice does not appeal to the author, as there seems to be little advantage to be gained by it, in that the portion of the fifth nerve grafted on to the sixth has been proved to be incapable of conduction.

Undoubtedly Harris and Low are right in advising the use of electrical tests before excising portions of the nerve, as by this means nerve tissue may be saved which would otherwise be destroyed. The benefit of analytical observation during operation is shown by a case in which Harris and Low made use of cross-union. The case was one of atypical Duchenne-Erb palsy:

A girl, aged two years, had suffered a few months before from "infantile paralysis or acute anterior poliomyelitis of the right shoulder," leaving behind paralysis and wasting, with reaction of degeneration in the deltoid, supraspinatus, and infraspinatus muscles. The biceps, brachialis anticus, and supinator longus were only slightly affected. From dissections and experiments on monkeys Harris and Low concluded that the "circumflex" bundle of nerve filaments occupies the upper half of the fifth root. In the case under discussion they made a longitudinal split in the fifth root, found that the faradic stimulation of the upper segment of the nerve gave the very slightest contraction of the biceps with definite weak contractions of the deltoid and triceps, while stimulation of the lower half gave powerful contractions of the biceps, causing strong flexion of the forearm, with no contractions at all in the deltoid. This being so, the "upper half of the nerve was formed into a flap having its base below (at the junction of the fifth and sixth roots) and the free end of the flap was anastomosed to a split made in the side of the sixth root."

Operations such as this one of Harris and Low have not yet stood the test of time, but their possibility and plausibility make them deserving of attention. In one of his cases Kennedy had a most gratifying result.

(B) **Indirect Method.**—*Tubby's Operation.*—("Brit. Med. Jour.," Oct. 17, 1903.) In some cases satisfactorily treated by Tubby no attempt was made to repair the damaged nerves, but disability was relieved by means of muscle transplantation or grafting. The operation is performed in two sittings:

(*a*) *Restoration of Elbow Flexion.—Step* 1.—Make an incision four to six inches long, from the middle of the back of the upper arm downwards and forwards towards the front of the elbow, and following the course of the musculo-spiral groove.

Step 2.—Expose and draw aside the musculo-spiral nerve. Demonstrate the outer part of the triceps muscle which arises above and to the outer side of the musculo-spiral groove. Detach a wide strip of the outer part of the triceps from its tendon, and separate it upwards for three to four inches, leaving this strip or flap attached to the rest of the triceps by its upper extremity.

Step 3.—Through the same incision expose the lower end of the biceps. At a point about two inches above the elbow make a tunnel through the muscle, from behind forwards. Flex the elbow to relieve tension. Pull the free end of the triceps flap through the tunnel in the biceps and fix it there with sutures.

Step 4.—Close the wound. Dress. Immobilize the elbow in a position of flexion. Do not permit any attempts at motion for one month.

(*b*) *Restoration of Shoulder Abduction.—Step* 1.—From a point one inch below the middle of the clavicle make an incision outwards to the tip of the acromion and then downwards for three inches. From the tip of the acromion make an incision upwards for two to three inches. Reflect the flaps outlined.

Step 2.—Demonstrate the clavicular portion of the pectoralis major; separate it from its attachment to the rest of the muscle; divide its insertion into the humerus, thus forming a muscular flap attached to the clavicle. Demonstrate and divide the insertion of the trapezius into the clavicle; separate the corresponding part of the muscle from the rest of the trapezius by splitting in the direction of the fibres. Thus a second muscular flap is obtained.

Step 3.—Bring the free end of the flap obtained from the pectoralis major upwards over the acromion process and fix it into the deltoid. With sutures fix a few fibres of the pectoral flap to the tip of the acromion so as to avoid slipping. If the flap is not long enough to reach and be united to the deltoid satisfactorily, make a vertical incision through the muscle to the bone, reflect upwards a flap of periosteum (as thick and large as possible), and unite this to the end of the pectoral flap. Suture the end of the flap obtained from the trapezius to the side of the pectoral flap. The result is a new muscle composed of contributions from the pectoralis major and the trapezius, inserted into the humerus in imitation of the deltoid.

Step 4.—Close the wound. Dress. Immobilize in a position of abduction. Do not put the newly grafted muscle on stretch for at least a month. After one month begin exercises with caution. Tubby has had some excellent results from this operation.

In certain cases of deltoid paralysis, other than Duchenne's, muscle transplantation may be valuable.

Hildebrand's Operation.—Instead of changing the site of insertion Hildebrand has changed the site of origin of the pectoralis major.

Experiments have shown that a muscle which has been almost entirely cut off from the circulation may be united with the body again and retain its function *provided* that its connection with the central nervous system is retained and that the blood supply of these nerve connections is intact. It is true that the majority of the muscle fibres degenerate as a result of the sudden limitation of the circulation, but the power of regeneration is completely preserved. These experiments teach that preservation of the nerve supply is much more important than preservation of the vascular connections of a muscle used in transplantation. Hildebrand used the above knowledge in the following case: A child, age four, suddenly became paralyzed in left shoulder fifteen months before.

Examination showed complete loss of function of the following muscles: Sterno-mastoid and trapezius (n. accessorius), deltoid and teres minor (n. axillaris), serratus anticus major (n. thoracicus longus), infraspinatus (n. suprascapularis). Flail joint. Arm hung loose, was rotated inwards and adducted.

FIG. 951.—Transplantation of pectoralis major. (*Adapted from Zuckerkandl.*)

Operation.—Step 1.—Make an incision through the skin from the sternal end of the fourth rib upwards to the sterno-clavicular joint, from here outwards immediately above the clavicle to the acromion and thence downwards over the bulge of the shoulder to a point near the insertion of the deltoid. Reflect downwards the skin flap thus outlined, so as to expose the pectoralis major and the deltoid very freely.

Step 2.—Divide the sterno-clavicular origin of the pectoralis major through its tendinous portion, *i.e.*, close to the bone. Separate the muscle completely from the chest-wall. With utmost care preserve the anterior thoracic nerves and the accompanying vessels which come from under the clavicle above and enter the deep surface of the muscle (Fig. 951). The muscle is now merely attached to the body by its insertion into the humerus and by its vessels and nerves.

Step 3.—Turn the flaps upwards and outwards so as to cover part of t deltoid and suture the divided origin of the muscle to the outer third of t clavicle and to the acromion after preparing these bones by cutting a groo in them. The muscle now extends from the clavicle (outer one-third) a acromion over the apex of the shoulder to the crest of the greater tubercle of t humerus, *i.e.*, it is in position to elevate the arm.

Step 4.—Close the skin wound. Apply dressings. Fix the arm in t horizontal posture (abduction) so as to relax the implanted muscle. A the end of six weeks the patient was able to bring the arm forwards nearly to th horizontal, and was able to touch her nose and the back of her neck. ("Archi für klin. Chir.," lxxviii, 75.)

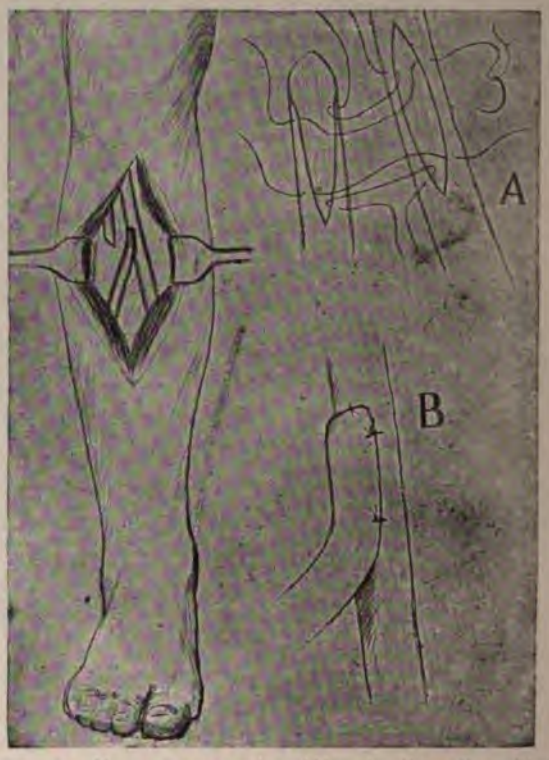


FIG. 952.—Nerve anastomosis. (*Murphy, Surg. Gyn. Obst.*)

Hoffa's Operations.—Hoffa has devised measures similar to those of Tubby His report ("Archiv für klin. Chir.," lxxxi, 473) is as follows:

1. A. M. 9. Right paralytic flail shoulder. Complete paralysis, deltoid.

Operation.—Separation of the trapezius from the clavicle, acromion a scapula. Union of the divided trapezius to the deltoid, the arm being co pletely abducted. Result good. The patient can raise the arm almost the horizontal, and the function is only slightly limited.

2. F. K. 2½. Obstetrical paralysis, right arm. Arm hangs loos downwards; internal rotation so marked that the elbow points forwards.

Operation.—Division of the insertion of the very tense pectoralis ma

ection of a part of the head of the humerus. Transplantation of the tra- ius into the deltoid. Result good. The internal rotation corrected; the i can be raised nearly to the horizontal so that the hand is easily put to the uth.

III. *Nerve anastomosis for anterior poliomyelitis.* Since it has been shown t a paralyzed nerve which is functionally separated from its motor centre till able to carry impulses if anastomosed with a functionally intact neigh- ing nerve, endeavors have been made by several surgeons to supply nerve nuli to the muscles paralyzed as a result of anterior poliomyelitis, by means ierve anastomosis. As very great and often unexpected recovery may take :e after paralysis from anterior poliomyelitis it is usually considered wise vait 6 months or more before deciding on operative interference.

Fig. 952 (Murphy) shows a type of operation which does not meet with the roval of men who gained much experience in the great war.

V. Dislocation of Ulnar Nerve at Elbow.—Momburg ("Archiv f. klin. .," lxx, 215) has shown that the ulnar nerve is frequently thrown out of groove on the inner epicondyle, especially during elbow flexion; that this itirely unimportant unless the nerve is irritated; that when there are irrita- and pain, the only cure is by operation. Several operations have given l results. Croft sutured the nerve to the triceps tendon and the fibrous ie covering the bone. McCormac isolated the nerve and fixed it by loops angaroo tendon to the triceps tendon. Several surgeons have formed flaps iscia or even of bone and periosteum (from the epicondyle) and with these ered the nerve in its groove. Momburg splits the triceps tendon and part ie muscle longitudinally; at the upper end of the split he divides the muscles he ulnar side of the split, pulls the flap thus formed around the nerve, and ires the muscle in its normal position. The nerve now passes through the eps and cannot be dislocated.

ALTERATIVE OPERATIONS ON NERVES

The most important methods employed to modify the structure or condi- i of nerves are nerve-stretching and the disassociation of fibres. In the er operation, after the nerve is exposed, its fibres are separated one from the er by blunt dissection; the indications and results are supposed to be similar hose of nerve-stretching, but the operation does not appeal to most surgeons. sociation may be better obtained by injecting into the nerve normal salt tion. Nerve-stretching has been used in many affections. Its employment is most valuable in neuritis (*e.g.*, sciatica), perforating ulcer of the foot, vari- ulcer (the ulcer being dystrophic, *i.e.*, due to a lack of nerve stimuli to the affected), angio-neurotic changes in the lower extremity, muscular spasm, in facial region. Various explanations of the modus operandi of nerve- tching have been given, the most reasonable being the breaking down of esions and the production of local hyperemia.

Sciatic Nerve.—The most suitable cases for nerve-stretching are those of tica due to exposure to cold and wet and in which the pain is limited to the ribution of the nerve.

The Operation.—Lay the patient in the prone position. Note by palpation

the tuber ischii and the great trochanter, midway between these points make a 4-inch longitudinal incision downwards from a point just above the gluteal fold. The centre of the cut corresponds to the lower edge of the gluteus maximus which is at a level lower than the fold of the buttock. Divide the fascia.

Demonstrate the edge of the gluteus maximus running downwards and outwards, and retract it upwards. Feel for and retract inwards the hamstring muscles after relaxing them by bending the knee.

The nerve is now exposed. Hook the nerve up with the finger and apply traction both upwards and downwards. The traction must be steady and strong. Enough power to lift the limb may commonly be exerted without danger, as the sciatic nerve can withstand a strain of about 80 pounds. Replace the nerve in its bed. Close the wound.

Internal Popliteal Nerve (Tibial Nerve).—*Step* 1.—From the centre of the popliteal space make a 3½ inch incision downwards over the interval between the two heads of the gastrocnemius. Retract the short saphenous vein and nerve. Divide the deep fascia.

Step 2.—Separate the two heads of the gastrocnemius. Flex the knee to relieve tension. Follow the short saphenous vein into the popliteal space; it goes directly to the popliteal vessels, superficial to which the nerve lies.

Step 3.—Hook up the nerve with the finger. Stretch it by pulling upwards and downwards.

External Popliteal Nerve (Peroneal).—Treves thus describes the exposure of this nerve:

"*Anatomy.*—The external popliteal or peroneal nerve follows the outer side of the popliteal space, lying close to the biceps. Passing over the outer head of the gastrocnemius, between it and the biceps, the nerve reaches the neck of the fibula, and crosses that bone beneath the fibres of the peroneus longus muscle. The nerve may be easily felt, when the knee is a little flexed, as a loose rounded cord, lying just behind the biceps, as it nears the head of the fibula.

"*Operation.*—The patient lies upon the sound side, with a sufficient tending to the prone position to well expose the outer aspect of the knee. The knee-joint is extended. An incision, one inch and a half in length, is made parallel with and immediately posterior to the tendon of the biceps. The cut should be so placed that its upper half is in relation with the tendon while its lower half is over the fibula. The skin and deep fascia having been divided, the biceps tendon is exposed. The knee should now be a little flexed and the nerve sought, close to the point at which the tendon reaches the head of the fibula. A narrow and unduly prominent ilio-tibial band has been mistaken for the biceps tendon."

Facial Nerve.—The facial nerve has been successfully stretched in the treatment of spasmodic tic. This operation is highly recommended by Kocher. Exposure of the facial nerve is sufficiently described in the chapter on nerve anastomosis.

Exposure of Musculo-spiral (Radial) Nerve.—This nerve requires exposure and treatment, in most instances, because of injury or compression due to fracture of the humerus.

Exposure of Nerve in Lower Part of Upper Arm.—*Step* 1.—Make an oblique incision about 3 inches long in the groove between the supinator longus and brachialis anticus muscles. The whole of this incision is in the lower third of the arm. Divide the deep fascia. Separate the two muscles (sup. longus; brachialis ant.) and expose the nerve which lies between them.

Step 2.—Follow the nerve upwards to the site of injury being careful not to injure the companion artery. In a case operated on by the author the nerve was stretched as a thin fibrous band over a sharp angle of bone for a distance of about ¼ inch. All objectionable pieces of bone were cut away; the nerve which was adherent to the bone was freed; a layer of brachialis anticus muscle was stitched between the nerve and the bone and the wound closed. The result was perfect after some months of appropriate treatment.

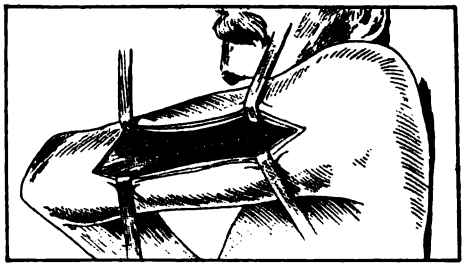


FIG. 953.—(*Schwartz and Kuss.*)

If for any reason it is impossible or improper to find the nerve below the site of injury, expose it above.

Exposure of Nerve in Upper or Middle Part of Arm.—From a point a little lower than the posterior axillary fold make an incision downwards over the interspace between the long head and the external (lateral) head of the triceps. Separate the two heads of the muscle by blunt dissection down to the bone against which the nerve lies accompanied by the profunda artery.

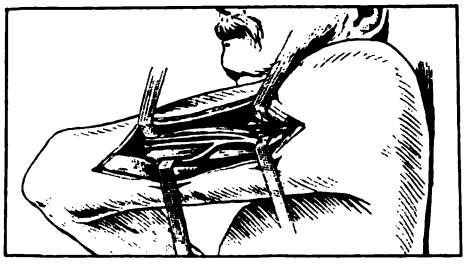


FIG. 954.—(*Schwartz and Kuss.*)

Schwartz and Kuss ("Revue de Chir.," No. 6, 1912) point out that the classical high exposure of the musculo-spiral nerve gives access to a very limited portion of it and gives no opportunity to follow the nerve downwards, while to expose the nerve low down and follow it upwards does much damage to muscle and to nerve branches. They advise the following operation.

Step 1.—Place the patient on his back; hold the arm vertically but slightly adducted; hold the forearm in a position of pronation and at right angles to the arm so that the hand rests on the chest inside the opposite axilla. Draw an imaginary line from the tip of the olecranon *exactly* in the middle line of the posterior surface of the arm to the prominent posterior border of the deltoid.

Step 2.—Make an incision through the skin along the imaginary line from a point four fingerbreadths above the tip of the olecranon upwards for from 12 to 18 cm. according to the supposed site of nerve lesion. Cut through the subcutaneous tissue and expose the deep fascia.

Step 3.—Carefully incise the brachial aponeurosis throughout the whole length of the wound and retract the edges of the aponeurotic wound. Note

that in the distal part of the wound on the ulnar side of the median line there is a V-shaped strip of tendon (tendon of the long triceps). The radial border of this V of tendon lies exactly along the olecrano-deltoid line described in Step 1 (Fig. 953).

Step 4.—Incise or split the muscluar fibres along the radial border of the V-shaped tendon between it and a quadrilateral layer of tendon (tendon of external head of the triceps) which does not extend so far up the arm (Fig. 953).

As soon as the tendinous tissue is carefully divided in the distal angle of the operative field a sort of muscular interstice is found lying between the outer head of the triceps (on the radial side) and the long head of the triceps (on the ulnar side). If the incision or the dissociation of muscular fibres is kept rigorously in the median line, as soon as the whole thickness of the triceps is penetrated a yellowish-white fascia presents, the thickness and consistence of which vary. This fascia binds the musculo-spiral nerve and its accompanying vessels to the humerus (Fig. 954).

Step 5.—Carefully divide the fascia and so expose the nerve from the axilla to where it penetrates the extenal intermuscular septum to reach the anterior part of the arm.

It sometimes happens that the ends of the divided nerve cannot be found or, *e.g.*, after fracture of the external condyle, there may be such a mass of callus pressing on the nerve that restoration of conduction seems too difficult or impossible—under such circumstances tendon transplantation may restore function.

At the International Surgical Congress in 1914, J. B. Murphy exhibited a patient who had suffered from the effects of division of the musculo-spiral nerve. Murphy to make the demonstration more striking "handled the truth a little carelessly" describing the treatment as if it had been neurorrhaphy. The result was accepted as excellent. He then confessed the excusable "pious fraud" and explained what really had been done. The Figs. 955, 956, 957, 958 and 959, with their legends clearly describe the operation. After suture of the superficial fascia and fat to prevent union between the tendons and skin, the skin wound is closed and the hand immobilized in extreme extension until union occurs. Complete restoration of function may be expected in four weeks—an enormous saving of time as compared with the year which must elapse before recovery after nerve suture.

FIG. 955.—Tenoplasty.

Shows the tendon of the flexor carpi radialis after division just below the annular ligament and elevated upward a distance of four inches beneath the skin and on the muscle tendon. The blunt scissors is passed It is spread as it is passed. The dotted line indicates the position in which the skin is to be incised and where the end of the tendon is to be drawn out.

FIG. 956.—Tenoplasty.
Shows the tendon drawn out in order to pass it over the brachioradialis and beneath the skin, and give it the proper angle for forceful contraction as an extensor muscle.

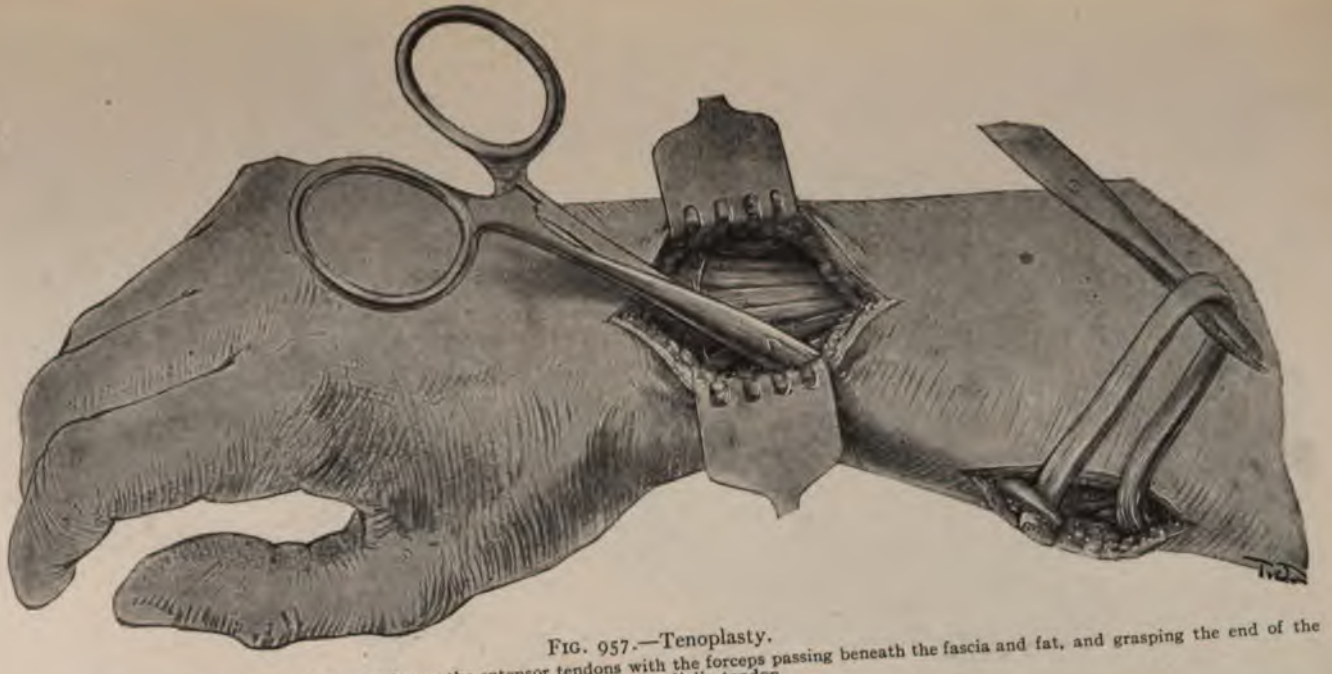


FIG. 957.—Tenoplasty.

Shows the incision on the dorsum of the hand over the extensor tendons with the forceps passing beneath the fascia and fat, and grasping the end of the flexor carpi radialis tendon.

FIG. 958.—Tenoplasty.

Shows the tendon of the flexor carpi radialis as it passes through the transfixed extensor longus and brevis pollicis, the two extensor tendons of the index-finger, and the extensor tendons of each of the remaining fingers. The line from *A* to *B* being only slightly deviated from the direct traction line of the tendon, so that the primary contraction of the tendon may be used continuously extending the thumb. The tendon from *B* to *C* is at right angles to the portion of the tendon from *A* to *B*, so that the index-finger and the thumb are extended and contracted without extending the middle, ring, or little fingers. When full contraction and full extension are made, then all five fingers are extended. One cannot extend the little or ring finger without extending the other three. One can extend and flex the thumb and index-finger without moving the other three.

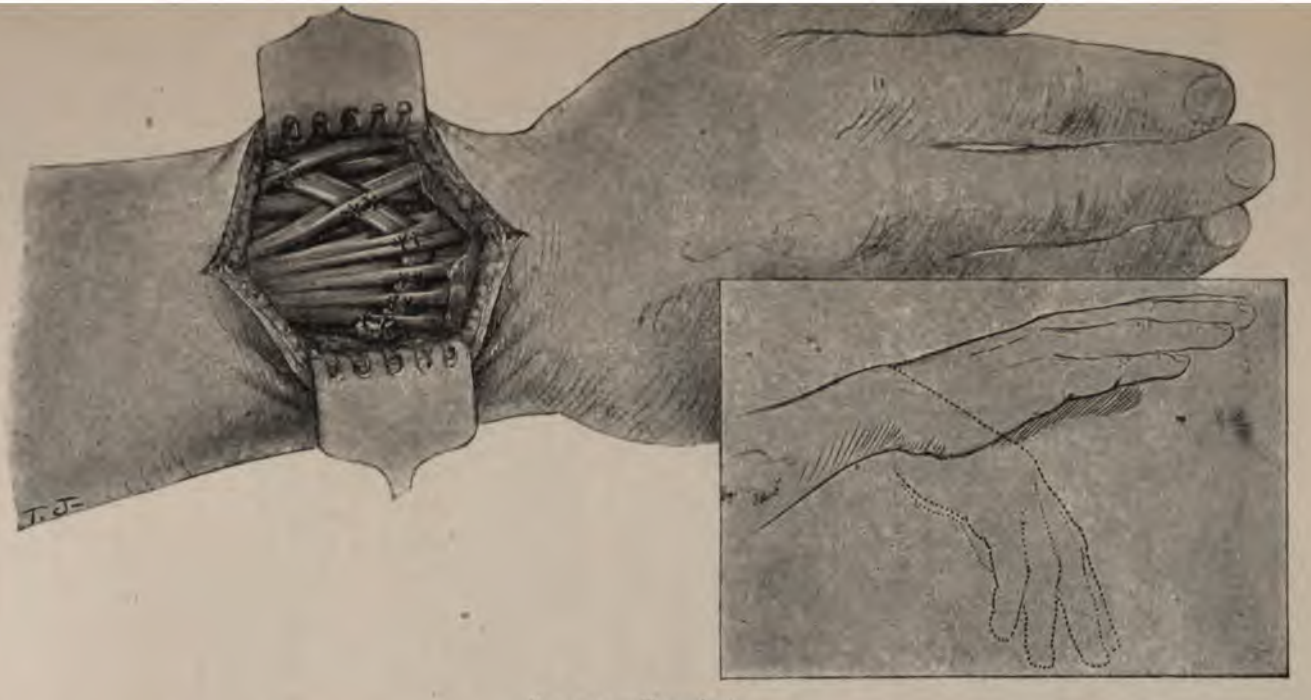


FIG. 959.—Tenoplasty.

Shows the sutures as placed in the extensor tendons, fixing them to the tendon of the flexor carpi radialis, so that they become an integral part of it. The insert shows the practical effect on the hand at the end of the third day after operation. The patient had full extension of all his fingers and the thumb, and he could extend the index-finger and thumb without extending any of the three other fingers.

CHAPTER LXI

ARTERIORRHAPHY

The subject of arterial suture is old. Hallowell and Lambert, in 1759, closed a small wound of the brachial artery by passing a pin through the edges of the wound and winding a thread round it as in the old hare-lip operation. Though born so long ago, arteriorrhaphy has only recently begun to grow, and even at present is, in many respects, merely in the experimental stage. The subject is so important, so many procedures are being transferred from the physiological laboratory to the operating-room, and it so often happens that in an emergency one wishes knowledge as to the possibilities and methods of arteriorrhaphy that the writer deems it wise to introduce a chapter dealing with it at this place.

For success in arterial suture the following things are essential: (1) *Perfect* asepsis. (2) A clean-cut wound. (3) Absence of tension on the sutures. (4) No rough handling of the vessel. (5) An efficient and *non*-injurious method of obtaining temporary hemostasis. (6) Good suture material.

Suture Material.—For a time catgut was the favorite material because when in site it became swollen and so filled the needle punctures that hemorrhage was prevented. The use of fine needles, without cutting edges (intestinal or seamstress' needles) seems to prevent hemorrhage sufficiently. To-day very fine silk is the suture of choice. Carrel finds it most important to impregnate the suture thoroughly with sterile vaseline so as to prevent the deposit of blood-clot on the thread. This lubrication of the thread, a trifle though it may seem, is probably the cause of the recent wonderful advances and successes in experimental arterial surgery. The needles used are fine round needles (intestinal, cambric, seamstress') which may be straight or curved. Carrel uses No. 15 or 16 needles. For sutures he formerly procured the finest silk thread possible, untwisted it and used one of the strands of which it was composed, this delicate strand constituted the suture after it had been impregnated with sterile vaseline. He now obtains silk of suitable fineness from Lyons.

Lilienthal uses No. 12 needles and No. ooo silk. Dorrance uses No. 1 Pagenstecher thread on the finest needle the thread will pass through.

METHOD OF TEMPORARY HEMOSTASIS

In a few cases the elastic constrictor may be used, in most cases its use must render the operation unnecessarily difficult or be distinctly harmful.

An assistant's fingers may be applied to the vessel above and below site of wound, but while such form the safest clamps yet they get in the way and are not so practicable as mechanical appliances.

Clamps.—Clamps the blades of which are covered with rubber tubing are serviceable. The best-known clamps are: (*a*) Broad-bladed, delicate, eight-

inch Billroth forceps (Murphy). (*b*) Miniature Doyen hysterectomy clamps (Dorrance) (Fig. 960). (*c*) Ordinary hemostats (Kümmel). (*d*) Herrick's clamp (Sweet). (*e*) Crile's clamp (Fig. 961).

FIG. 960.—Dorrance clamp.

Tapes, etc.—Fine linen strips thrown around the vessel and fastened by forceps instead of by a knot (Carrel and Guthrie). Fine, thin tape fastened by forceps or serre-fins (Lilienthal). Heavy twisted silk used in the same manner.

Whatever means of hemostasis is used, it must be used most gently. The forceps or tape must only exert enough pressure to control the circulation and not one iota more. Crushing or injury to the intima is fatal to success.

SUTURE OF ARTERIES

Temporarily occlude the artery about 1 inch above and below the wound with clamps or tapes.

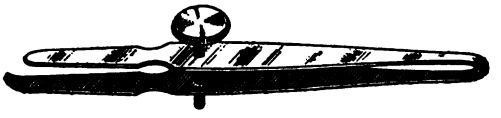


FIG. 961.—Crile's clamp.

Gently but thoroughly remove all blood whether clotted or not; in doing this use the normal salt solution. Examine the edges of the wound; if they are lacerated or contused pare them. For this purpose Carrel uses fine scissors. Coat the vessel both inside and out with vaseline (Carrel). Carefully resect or remove the external sheath of the vessel from the neighborhood of the wound. If any

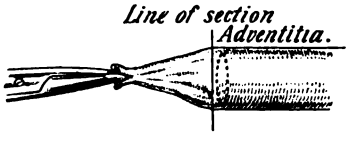


FIG. 962.

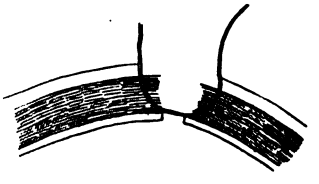


FIG. 963.

fibres of this fibrous tissue tunic get between the edges of the wound and into contact with the blood, a thrombus will quickly form. The easiest method of resecting the outer coat is to pull it forwards over the inner coat and clip it off with scissors (Fig. 962).

Methods of Suture.—Interrupted or continuous sutures may be chosen at the option of the operator; the continuous suture is the favorite.

Method A.—Pass the suture as in Fig. 963 without damaging the intima. This is possible in large arteries, but impossible in medium-sized ones or in veins. The disadvantages of the method are the limitations of its applicability; difficulty; the possibility of fibrin ferment passing from the arterial walls

to the blood-stream; the possible presence of fringes of intima hanging into the blood-stream and favoring coagulation and the possibility of blood passing through the open intima, infiltrating the vessel-wall, thus causing aneurysm.

Method B. Through-and-Through Sutures.—Close the wound by sutures penetrating all the coats of the vessel, taking care "not to include fragments of the connective-tissue layer in the line of suturing, and to obtain a smooth union and approximation of the endothelial coats" (Carrel).

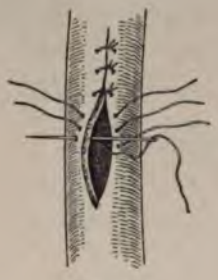


FIG. 964.

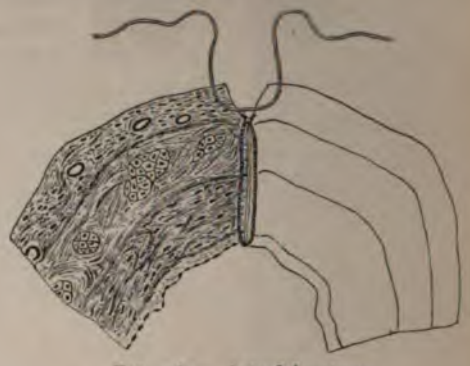


FIG. 965.—Arterial suture.

Figs. 964 and 965 are self-explanatory. During the passage of the sutures the extreme edges of the wound may be held in delicate dissecting forceps. A thimble is useful in pushing the needle through the tissues. This method has given many excellent results. The line of union may be strengthened by separate suture of the adventitia.

Method C. Brieau-Jaboulay Suture.—This suture is highly commended by Archibald Smith, and a practically identical stitch has been advised by Dorrance.

The suture produces eversion of the lips of the wound and brings intima into contact with intima. *Prima facie* one would think such a suture would produce stenosis, but A. Smith's researches show that such is not the case.

FIG. 966.

Pass a stitch from without inwards through all the coats of the wounded vessel at the point a (Fig. 966); pass the same thread from within outwards through all the coats of the opposite side of the wound at the corresponding point b. Reintroduce the stitch from without inwards at c, and complete its course by bringing it from within outwards through the whole thickness of the vessel-wall at d. This leaves in place a U-suture which everts the lips of the wound. In a short wound or puncture one U-suture may suffice; in a longer wound several will be necessary, each tied separately or placed in a continuous fashion.

Method D. Brewer's Adhesive Plaster.—George Brewer, having had ill results from arterial sutures failing to hold, has wrapped wounded vessels with an "elastic plaster made up of a strip of very thin gum (rubber), coated with an

adhesive material like that used in the zinc oxide plaster. Experiments were made on a large number of animals and some of the results were good." The method does not seem to have been used in practice. The objections to the method are: Difficulty in applying the plaster with sufficient and not too much tension; the almost certain absence of the material when it is required; a foreign body being left in the wound.

END-TO-END ARTERIAL ANASTOMOSIS

Circular arteriorrhaphy is of value when an artery of size has been completely divided or a portion of it has been excised. The same general rules laid down for suture of arterial wounds apply to the operation about to be described.

Sweet prepares the divided ends of the vessel for suture by carefully removing the loose connective-tissue sheath (adventitia) about the ends of the vessel (Fig. 962). "This can be done very nicely by grasping the sheath with forceps, drawing it over the end of the vessel and clipping it off with scissors." During the operation keep the vessels from drying either by moistening with salt solution or by applying sterile vaseline. When the suture is complete and the blood allowed to resume its circulation there is rarely any bleeding, and such as there is is easily controlled by temporary pressure.

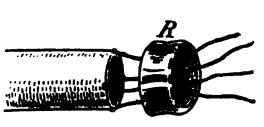


FIG. 967.

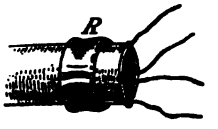


FIG. 968.

FIGS. 967 AND 968.—Payr's magnesium rings.

Payr's Method.—*Magnesium Prosthesis.*—Have at hand a number of rings grooved on their outer surface, of different sizes and made of very thin magnesium.

Step 1.—To the cut edges of the central segment of artery apply four fine silk sutures penetrating all the coats of the vessel (Fig. 967).

Step 2.—Choose a ring which will fit accurately round the artery. Pass the four threads through the ring (Fig. 967). With the threads pull the artery through the ring until an amount of artery protrudes from the ring rather greater than the width of the ring (Fig. 968).

Step 3.—Aided by the threads, turn the protruding cuff of artery backwards over the ring and fix it in place by tying a fine ligature round it (Fig. 969). The groove in the ring prevents the ligature from slipping.

Step 4.—Introduce four sutures into the cut edge of the peripheral segment (Fig. 970).

Step 5.—Make traction on these four threads and so distend the lumen of the peripheral segment (Fig. 969). Push the central segment (with its rings) into the distended peripheral segment. When the peripheral segment covers [redacted] fix it in place with a ligature (Fig. 971).

This completes the operation. It will be seen that the ring, though buried, is extra-vascular. Magnesium is dissolved and absorbed in the body, hence no persistent foreign substance is left in the wound. (Payr, "Archiv für klin. Chir.," lxii, 1; lxiv, 3; lxxii, 1.)

Murphy's Method.—*Invagination.*—*Step* 1.—Introduce a fine cambric needle, armed with fine silk, through all the tunics of the distal segment of the vessel

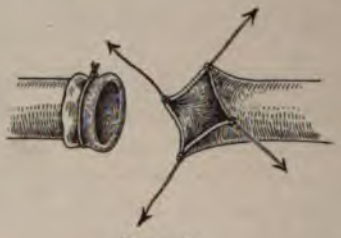


FIG. 969.

FIG. 970.

FIGS. 969 AND 970.—Payr's magnesium rings.

from without inwards at the point A about ⅓ inch distant from the divided edge of the vessel (Fig. 972). Bring the needle out through the open end of the vessel. With the needle pick up a small portion of the adventitia and media (not the intima) at the point C, near the cut edge of the *proximal* segment of vessel. Introduce the same needle through open lumen of the peripheral segment and make it penetrate, from within outwards, the whole thickness of the vessel at a point close to A. The result of this is a **U** or mattress suture. Introduce two other sutures in the same manner so that three **U**-stitches are in position at equal distances from each other.

FIG. 971.—Payr's magnesium.

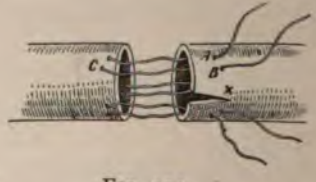


FIG. 972.

FIG. 973.

FIGS. 972 AND 973.—Murphy's method.

Step 2.—Pull on the three **U**-sutures and so invaginate the proximal into the distal segment of vessel (Fig. 973). Tie the sutures. Before invaginating it may be necessary to make a slight longitudinal split (x) in the receiving or distal segment.

Step 3.—With fine sutures unite the edge of the distal to the side of the proximal segment at the line where the former overlaps the latter. If a longitudinal split has been made, close it also with a stitch.

Step 4.—Carefully suture any available tissues near the vessel in such fashion as to give the maximum of support to it.

Eversion Method. Brieau and Jaboulay's Sutures Modified by Dorrance.—"The clamps are applied as before.* The cut edges of the artery are grasped

* The clamps used by Dorrance are miniature copies of Doyen's hysterectomy clamp.

FIG. 974.—(*Dorrance.*)

FIG. 975.—(*Dorrance.*)

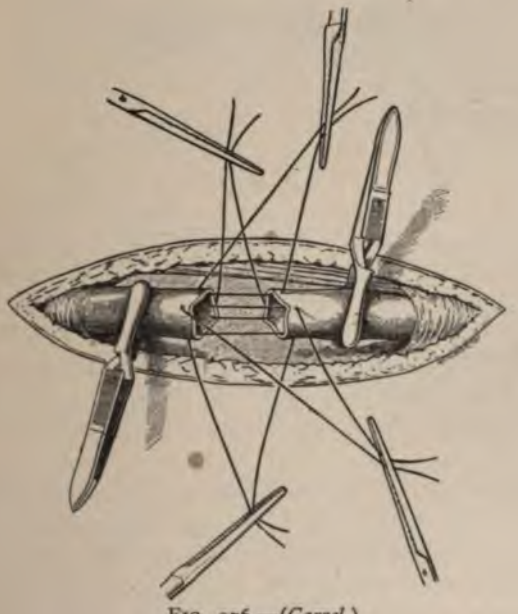


FIG. 976.—(*Carrel.*)

with dissecting forceps, and the suture is passed through the upper edge of the artery from without in and through the lower end from within out; the needle is then reversed and brought back 1.5 mm. to one side of the former suture and tied. (This suture is really a single mattress suture.) The suture is continued as a continuous mattress suture, dropping back half a stitch every third suture until the starting-point is reached; then a half stitch is made and the suture continued back as a whip-stitch until the starting-point is reached again; then the two ends are tied (Figs. 974 and 975). The suture is started on the anterior surface near the handles of the clamps. When the suture reaches the farther side of the artery the handles of the clamps are taken from the lower portion of the wound and placed in the upper portion. In this way the surface of the artery which was anterior is now posterior, and the suture can always be kept in sight."

Carrel's Method.—*Step* 1.—Introduce three tension sutures of very fine silk impregnated with vaseline at equidistant points of the circumference of the vessel ends (Fig. 976).* These sutures penetrate the whole thickness of the vessel-walls.

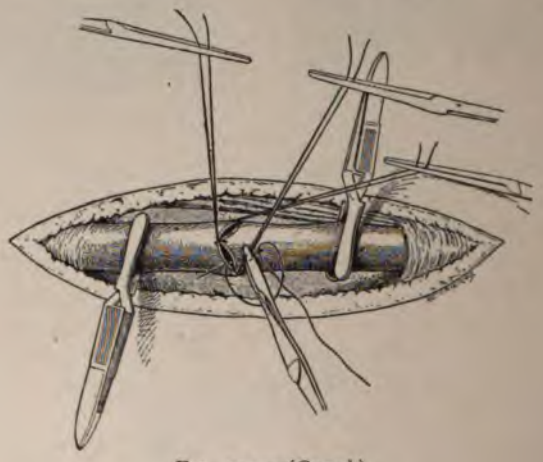


FIG. 977.—(*Carrel.*)

Step 2.—Have an assistant apply traction to two of these sutures so as to stretch the portion between the two sutures into a straight line and to approximate the corresponding cut edges of the vessel. Apply a hemostat to the third tension suture and let it hang so as to pull on the suture. The slight pulling on the three sutures arranges the circumference of the vessel as a triangle, and this facilitates suturing.

Step 3.—Introduce a continuous overhand stitch through all the coats all round the vessel. The stitches should be very close together and only drawn tightly enough to secure approximation, but not tightly enough to produce eversion of the edges of the wound (Fig. 977).

Step 4.—Remove the distal clamp (used for provisional hemostasis). Remove the proximal clamp. If there is any bleeding, gentle finger pressure will

* In the illustration four tension sutures have been employed.

almost always stop it (Fig. 978). If necessary for hemostasis, introduce one or two interrupted sutures.

Step 5.—Close the wound after putting one or two stitches in the adventitia to reinforce the main arterial suture.

FIG. 978.—(*Carrel.*)

VENOUS IMPLANTATION

When the severed ends of the artery are so distant that approximation is impossible one may bridge the defect by implanting a segment of vein. E. Lexer ("Archiv für klin. Chir.," lxxxiii, 459) reports a case of axillary aneurysm which he excised; approximation of the ends of the artery being impossible, he excised a branchless segment of the great saphenous vein, united its distal end to the proximal segment of artery and its proximal end to the distal portion of artery. The union was effected after Carrel's method. There was no hemorrhage and no thrombosis at the line of suture. The segment of vein seemed to act well. Experiments have shown that veins when substituted for arteries become thickened, stronger, and adapt themselves to their new duties.

Some of Carrel's experiments on dogs and cats show admirably the possibilities of operations on the vascular system. At the Rockefeller Institute, New York, Carrel exhibited to the members of the Society of Clinical Surgery healthy looking animals on which the following operations had been performed: (*a*) Excision of segment of abdominal aorta, a corresponding segment of vena cava being inserted to take its place. (*b*) Excision of segment of abdominal aorta, a corresponding segment of an aorta which had been kept in cold storage for some days being implanted into the gap. (*c*) Double nephrectomy—both kidneys being replanted. On suture of the vessels and ureters secretion of urine quickly manifested itself. (*d*) Amputation of the thigh of a black dog—implantation of the corresponding amputated thigh of a white dog on to the stump. When exhibited healing was not complete, but circulation was established in the implanted thigh.

Some of the operations described in the preceding paragraphs almost appear as if they were the offspring of a superheated imagination, but many of them have been applied in surgery with most conservative and gratifying results. It may be well and encouraging to briefly note a few cases in which the methods devised after animal experimentation have been applied to man.

Frank T. Stewart ("Annals of Surg.," July, 1908) reports two cases of resection of the brachial artery, one by the Murphy method with probable thrombosis, the other by Carrel's method with success.

Kümmel, during an operation for malignant disease, excised about 1¾ inches of the femoral artery. He successfully repaired the vessel by invaginating the central into the peripheral end.

E. Martin ("Med. Klinik.," 1908, No. 38) performed circular arteriorrhaphy (Carrel's Method) after resection of 1¼ inches of the brachial artery injured by a trauma near the elbow. After union a slight murmur was audible over the scar.

Braun ("Archiv für klin. Chir.," lxxxvi, 707), while removing a retroperitoneal tumor, made an oblique tear in the aorta. The tear involved about half the circumference of the vessel, the walls of which had been thinned from pressure by the tumor. In anticipation of injuring the aorta the vessel had been provisionally compressed. Suture of the wound by a single layer of stitches was insufficient to prevent bleeding, and a second row when introduced produced too much stenosis (absence of femoral pulse, coldness of limbs), so Braun excised the injured segment of aorta and united the cut ends by Carrel's method. A small iodoform gauze tampon was placed against the line of suture and the abdominal wound closed around the tampon. The tampon was removed on the eighth day. The patient was confined to bed for four weeks. Three months later the patient was well.

On Aug. 1, 1917 an English soldier had his popliteal artery wounded. Two months later Harold Neuhof exposed the vessel which was the site of a false aneurism and repaired it with a patch of fascia lata. On Aug. 1, 1918 the soldier was seen driving a camion at La Ferte Milon and presented no symptoms of trouble. Neuhof wrote Feb. 21, 1920: "I can now give you a report on the results of operation in two cases of traumatic aneurism treated by resection of the sac and transplantation of fascia lata into the arterial defect. In both cases there was return of circulation into the limb without any evidence of interference with the circulation. Operation having been done in both instances more than two years ago and the reports recently received indicating no evidence of recurrence, I believe the result can be termed perfect and permanent in both."

TREATMENT OF THROMBOSIS AND EMBOLISM BY OPERATIONS ON THE VESSELS

It is necessary to distinguish between closure of an artery by a clot forming on an injured or diseased intima and closure due to an embolus lodging in a more or less healthy artery. In the first case removal of the blood-clot alone is valueless, as another clot will form immediately. If the injured or diseased portion of vessel is of a very limited extent, that portion may be excised and the divided ends of the vessel united by arteriorrhaphy or by the implantation of a segment of vein. If venous implantation is attempted do not use the companion vein to supply the defect; this would be calculated to seriously interfere with the return circulation. Probably in thrombosis it may be better to send blood down into the limb through a vein (reversal of circulation), as will be described later. When the closure of the artery is due to the lodgment of an embolus, it is logical to open the vessel by a longitudinal incision after providing for temporary hemostasis, extract the clot, wash the interior of the segment of vessel segregated by the hemostatic tapes or clips with salt solution, smear it with sterile vaseline and close the wound with sutures. Frank Stewart reports an unsuccessful case of such an operation ("Annals of Surg.," Sept., 1907). To be

successful it is necessary that the diagnosis of obstruction by embolism be made early and operation be promptly carried out. Of course the procedures mentioned are not at all established, but it is necessary for operating surgeons to bear them in mind. Instead of attacking arterial obstruction directly the surgeon may to some extent reverse the circulation in the limb and so dodge the impediment.

Bauer ("Zent. f. Chir.," xx, Dec., 1913) reports the case of a man aged thirty who experienced a sudden severe pain in both legs with complete loss of function. The limbs became blue and cold. After the lapse of three hours the abdomen was opened and the aorta was found pulseless at the level of its bifurcation. A clot having two short prolongations into the iliac vessels was removed by arteriotomy from the aorta and the vessel was closed by suture. The circulation was established satisfactorily and the patient went home on the twenty-fifth day.

J. C. Hubbard ("Annals Surg.," Oct., 1906, and Sept., 1907), in a case of gangrene of the foot, isolated the femoral artery and vein at the apex of Scarpa's triangle below the origin of the profunda and divided them after providing for temporary hemostasis. He invaginated the upper end of the artery into the lower end of the vein as in Murphy's method of arteriorrhaphy. After the operation there was no œdema, dilatation of the veins, or cyanosis. The gangrene present before operation spread a little and then a line of demarcation formed. When the foot was later amputated at the point of election on the tibia, both tibial arteries contained arterial blood. The stump healed satisfactorily but slowly. Hubbard writes: "It seems that the arterio-venous anastomosis must have increased in some way the amount of blood in the leg, for it is hard to believe that an amount of blood so small as to permit gangrene of the foot would be sufficient to nourish for ten months an amputation stump made only a short distance above the gangrenous area, and had thrombi formed at the sites of the anastomosis, it seems most probable that the gangrene would have extended up the leg instead of remaining localized."

Doberauer reports a case of embolism of the right axillary artery. The trouble had lasted fifty-two hours, and there was already present a commencing gangrene and ischæmic contracture of the limb.

Doberauer performed arteriotomy, removed a clot about 3 cm. in length and sutured the artery. A new clot formed in a few hours and was removed in the same manner. Once more the thrombus reformed and after two days the gangrene notably progressed.

Arterio-venous anastomosis was now made between the axillary artery and vein. As soon as the anastomosis was completed and the blood current permitted to flow, "one perceived the eruption of the arterial blood into the vein in the form of a little explosion and one saw the blood advance to the level of the wrist." The vein pulsated like an artery. Twelve days after operation the circulation remained good.

In a patient who had lost his left leg from gangrene due to arterial sclerosis, marked symptoms of the same affection appeared in the remaining lower limb. Wieting Pasha exposed the femoral artery and vein at the apex of Scarpa's triangle, divided the artery completely, and introduced its central portion into

the femoral vein for a distance of at least ⅜ inch (1 cm.) through an incision made on the anterior surface of the vein. The union was effected by sutures which penetrated the whole thickness of the wall of the vein but only the outer coats of the artery. The vein was ligated above the point of anastomosis. The foot soon became warm and rosy. Two months after the operation the circulation remained satisfactory ("Deutsche med. Woch.," 1908, No. 28).

In October, 1908, J. B. Murphy exhibited to the Society of Clinical Surgery a patient in whom he had successfully established arterial circulation through

FIG. 979.

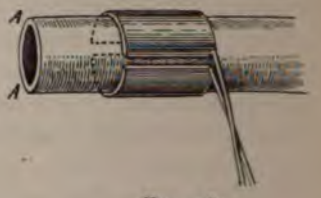


FIG. 980.
A. A. Cut edge of vein.

FIGS. 979 AND 980.—Murphy's anastomosis forceps.

the femoral vein for gangrene of the foot due to endarteritis. He operated as follows:

(1) Exposure of the femoral artery and vein and division of both. (Divide the vein at a slightly higher level than the artery.)

(2) Apply forceps (Fig. 979) around the distal segment of the vein near its end (A, Fig. 980). Pull the open end of the vein back over the forceps (Fig. 981).

(3) Suture the open end of the proximal segment of the divided artery to the inside of the vein where it is reflected over the forceps (B, Fig. 951).

FIG. 981.
B B. Sutures through cut edge of artery and folded edge of vein.

FIG. 982.

(4) Pull the reflected portion of vein over the line of suture (Fig. 982) and suture its cut end to the surface of the artery.

(5) Remove the forceps.

In speaking of the operation Murphy said that it would have been better to have made a lateral anastomosis between the artery and vein and then to have tied the vein proximal to the site of anastomosis; by so doing it would have been possible to continue sending blood down the stenosed artery while arterial blood passing down the vein would supply the deficiency created by the narrowing of the artery.

Bernheim ("Annals Surg.," Feb., 1912) has collected 52 cases of arteriovenous anastomosis. Fifteen of these (30 per cent.) were successful, the reversal, as far as could be judged, actually saving the limb from present or threatened gangrene.

CHAPTER LXII

ANEURYSM

A short discussion of the forms and varieties of aneurysm may be of benefit, as clarifying the consideration of their treatment. While trauma is an important cause of aneurysm, *e.g.*, gun-shot wound causing arterio-venous aneurysm, yet a weakening of the arterial wall from disease is by far the most common cause of the trouble.

(A) When an artery ruptures, whether from trauma, disease, or both, bleeding into the surrounding tissues takes place, resulting in a hematoma. If the wound in the vessel heals there may be no further trouble; if the wound does not heal and if from pressure, etc., the tissues surrounding the effused blood become condensed so as to form a capsule, then a pulsating, well-defined tumor is formed, the cavity of which communicates directly with the lumen of the wounded artery. This pulsating tumor is known as a *false aneurysm.*

(B) When an artery and a vein lying alongside each other are simultaneously wounded and the wound is treated by compression, the two vessels may adhere; the superficial wound may heal; the openings into the vessels may not close, but may form an arterio-venous anastomosis, the arterial blood passing directly into the vein. This condition is known as an *aneurysmal varix* and may or may not occasion any trouble. Instead of adhering one to the other, the artery and vein may each bleed into the surrounding tissues and give rise to a false aneurysm which communicates directly with the lumen of each vessel, so that the arterial blood passes from the artery to the vein through the intermediate sac. This condition is known as a *varicose aneurysm* and is of more moment than aneurysmal varix. The two varieties, viz., varicose aneurysm and aneurysmal varix, have the common name *arterio-venous aneurysm.*

(C) **Cirsoid aneurysm** is a condition in which a number of dilated arteries, held together by connective tissue, form a tumor which is the arterial equivalent of the venous varicocele. The disease is most common in the scalp, and its treatment is very similar to that of angioma.

(D) **True Aneurysm.**

1. When disease (*e.g.*, atheroma) weakens the whole circumference of an artery, dilatation is liable to take place (Fig. 983, 8, 9, 10). The whole circumference being affected, the dilatation is uniformly fusiform except in so far as it is affected by surrounding supporting structures (Fig. 983, 11, 12, 13). This is a *fusiform aneurysm.*

2. When disease weakens a *limited portion of the circumference* of an artery, a pouching of the arterial wall outwards is liable to take place, just as a bulging or pouting of a pneumatic tire forms when a limited portion of the tire has become weakened (Fig. 983, 1, 2, 3, 4, 5, 6, 7). In this manner a larger or smaller sac is formed communicating with the lumen through a more or less circular opening or cleft in the vessel-wall. This variety is known as a [illegible] 983, 3). If the sac of such an aneurysm

is opened, only one orifice may be seen leading into the artery; if two orifices are visible, they are connected by a groove in the wall of the sac leading from one orifice to the other (Fig. 983, 7). This groove consists of normal artery wall, and in fact is the artery which communicates with the sac through a split of limited width instead of through an opening of limited length and width (Fig.

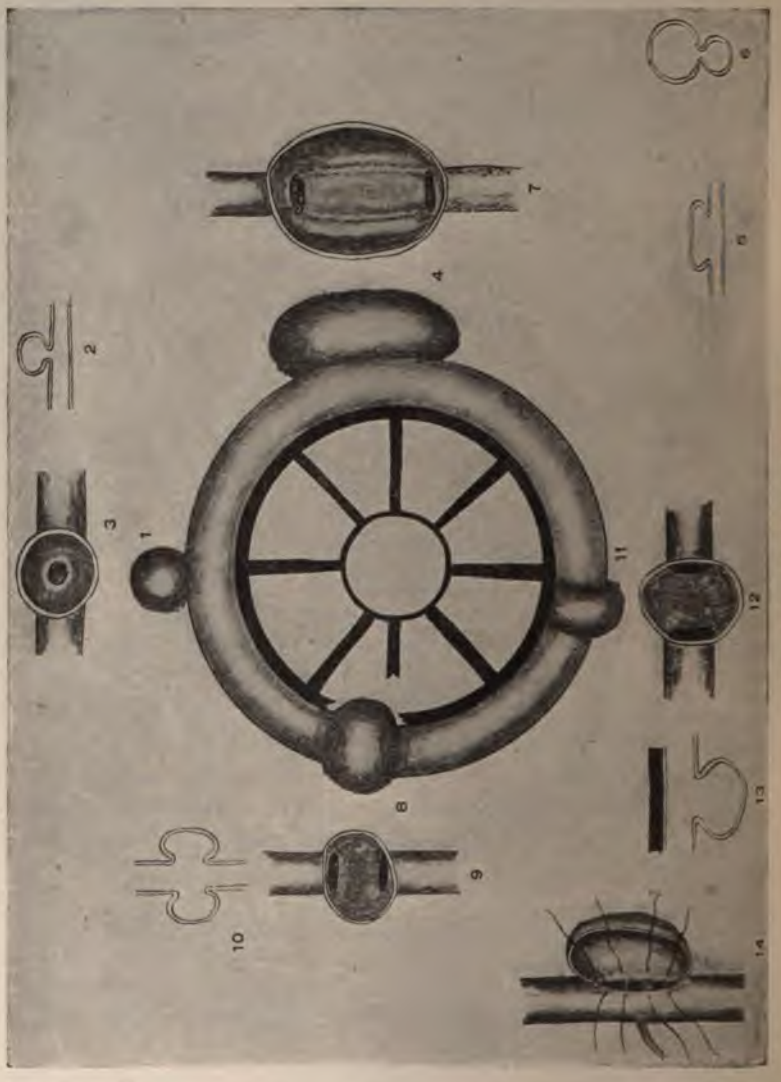


Fig. 983.—Varieties of aneurysm.

983, 14). A recognition of these facts is very important, as such aneurysms may be suitable for reconstructive operations, while fusiform aneurysms with which they are often confounded are entirely unsuited to such treatment.

(E) A true aneurysm may rupture and form a false aneurysm in addition. This must be remembered as the condition may puzzle an operator when performing endo-aneurysmorrhaphy.

LIGATION

(*a*) **Operation of Antyllus.**—Expose the aneurysm along with the artery mediately above and below it (Fig. 984). Ligate the artery immediately ve and below the aneurysm. Open the sac; turn out contained blood-clots; se as much of the sac as convenient; close the wound. This operation is ly performed except in very superficial vessels. Other and better methods available, but the procedure is worthy of note as being the earliest form of ration and being very closely allied to some of the most modern.

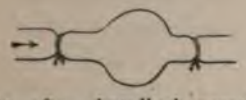


FIG. 984.—Antyllus' operation.

FIG. 985.—Anel's operation.

(*b*) **Anel's Operation.**—Expose the artery proximal to the aneurysm. Li- close to the aneurysm, so close, in fact, that no branch is given off from artery between the ligature and the sac. The objections to this operation that the ligature is applied on more or less diseased tissue (not a very grave lt in view of the success of Matas' operation) and that blood may soon enter sac through collateral circulation (Fig. 985).

(*c*) **Hunter's Operation.**—To avoid ligating diseased tissue John Hunter rated at a distance from the aneurysm. In popliteal aneurysm he ligated femoral in Hunter's canal; later surgeons preferred to ligate at the apex Scarpa's triangle. Collateral circulation does not pour blood into the sac arly as after Anel's operation (Fig. 986).

FIG. 986.—Hunter's operation.

FIG. 987.—Brasdor's operation.

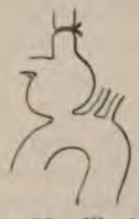


FIG. 988.—Wardrop's operation.

(*d*) **Brasdor's Operation.**—When an aneurysm is so near the trunk that ximal ligation is impracticable, distal ligation may form a barrier to the low of blood, collateral circulation may be established, and a cure result. Brasdor's operation consists in ligating the main artery distal to the aneu- m (Fig. 987).

(*e*) **Wardrop's Operation.**—When, for example in innominate aneurysm, artery divides into two great vessels, the circulation may be sufficiently cked by the ligation of one of these vessels distal to the disease (Fig. 988). s is Wardrop's operation. If ligation of the one vessel prove insufficient, the

other branch may be tied as well so that the same condition prevails as in Brasdor's operation.

(*f*) **Syme's Operation** is practically obsolete. It consisted in incising the aneurysm freely, quickly inserting the finger so as to plug the afferent vessel and then in catching with a forceps, through the cavity of the sac, the mouth of the vessel, and subsequently obliterating it with a ligature or stitch.

(*g*) **Dix's Operation.**—("Brit. Med. Jour.," Oct. 30, 1875, and "Bryant's Surg.," 3d ed., i, 449.) Gradual constriction of the afferent artery. This method has been much neglected, and yet it has many valuable features. It imitates nature's cure by gradually decreasing and then stopping the onflow of blood. If coldness of the limb indicates that the circulation has been interfered with too much, the constriction may be loosened slightly and an opportunity given for a sufficient establishment of collateral circulation. Stratton, Halstead and Matas have used this same principle in various ways.

Expose the artery, encircle it with a strand of soft silver wire about nine inches long. With a needle pass the ends of the wire, from within outwards, through the tissues to the surface so as to emerge on the skin, one about a quarter of an inch and the other three-quarters of an inch from the edge of the wound, *both being on the same side of the wound.* Divide a small cork longitudinally; place one-half of this between the emerging ends of wire, flat surface to skin, with its long axis exactly in the line of the artery and press down upon it; twist the ends of the wire over the cork until pulsation ceases in the aneurysm. Close the skin wound. "When depression of anesthesia goes off and the circulation revives, it will be found that a feeble pulsation returns in the aneurysm. This, according to the author (who strongly advocates the *gradual* rather than the *rapid* method of producing coagulation in the sac), should be allowed to go on for two or even three days, when the wire is to be tightened" (Thomas Bryant.) To tighten the wire, press down on the cork and slip small wedges of wood (matches would do) between the wire and the cork. Do not twist the wire afresh lest it break. "About the fifth or sixth day the cure is complete" and the wire may be removed.

EXCISION OF ANEURYSM

Adolf Treutlein ("Munch. med. Woch.," June 19, 1906) recommends that in traumatic aneurysm finger pressure be used to the affected part two or three times daily for fifteen minutes during a period of about two weeks prior to operation. The object of this preliminary treatment is to encourage the development of collateral circulation and lessen the dangers of gangrene. Ellsworth Eliot, Jr., has preached this doctrine for years. Freely expose the aneurysm by incision. Ligate the artery proximal to the sac. If practicable ligate the artery distal to the sac. Remember that branches may be given off from the sac and that these may bleed. Excise the sac as if it were a *non*-malignant tumor. It may be easy to remove the aneurysm without opening it, it will generally be much easier if the sac is opened and its contents evacuated not merely because of increased ease in manipulation, but because the openings of the branch vessels may be visible and thus their exposure and ligation be facilitated. In old aneurysms with their numerous irregularities and adhesions extirpation may be very

difficult. When the wall of the sac is closely adherent to important structures rather leave a portion of the sac *in situ* than jeopardize such.

If temporary hemostasis has been obtained by an elastic constrictor, hemorrhage is likely to be so considerable on its removal that Hildebrand gives the following advice: Tampon the wound and elevate the limb before removing the constrictor. Remove the constrictor. After about 10 to 15 minutes the temporary hyperemia always noticeable after removal of a constrictor will have disappeared, and it becomes easy to pick up and tie all bleeding points.

The development of arteriorrhaphy renders it possible to substitute a more ideal operation for the classical method of excision of an aneurysm. Instead of ligating the artery above and below the aneurysm, it is temporarily occluded by means of Crile's clamps or the like (unless Esmarch's elastic constrictor has been used); the aneurysm is excised and the afferent and efferent segments of the artery are united by suture.

Enderlen (Würzburg) ("Deutsche med. Woch.," 1908, No. 37), excised a popliteal aneurysm. The vein was twice wounded during the dissection and both wounds were sutured. The aneurysm was isolated—all collateral branches were ligated and the sac excised. Flexion of the knee permitted approximation of the divided ends of the artery which were united by Carrel's suture. During after-treatment the knee was kept flexed. After union was assured the knee was gradually extended. At the end of six months the patient resumed work. If it be impossible to approximate the divided ends of the artery the gap may be filled by implanting a segment of vein(*e.g.*, long saphenous). This method was successfully adopted by E. Lexer after he had excised an aneurysm of the axillary artery. Einar Key (Zentralblatt für Chir., Oct. 14, 1911) in extirpating a popliteal aneurysm, excised fully 4 cm. of the artery. The knee was flexed to 45°, and arteriorrhaphy performed. After 4 weeks the knee could be extended.

OBLITERATIVE ENDO-ANEURYSMORRHAPHY (MATAS)

In situations where temporary hemostasis can be surely secured by the elastic constrictor or some form of compressor, or where all the main vessels entering or leaving the aneurysmal sac can be secured either temporarily by clamps such as Crile's or permanently by ligatures, Matas's operation is easy and efficient.

Step 1.—After assuring temporary hemostasis, make a free incision parallel to the long axis of the aneurysm down to the sac. Do not injure any important structures.

Step 2.—Freely incise the sac so that every part of it is accessible to sight and touch. Remove the contents of the sac and retract its walls so that all the orifices which open into it are visible. Note if there are two main orifices unconnected by a groove of more or less normal arterial wall. If this is the case the aneurysm is fusiform and suitable for the obliterative operation. If the two openings are connected by a groove of more or less healthy arterial wall, note if this groove is wide and contains enough and sufficiently good tissue to permit reconstruction of the artery. If the groove is narrow and composed of suspicious tissue, the aneurysm is either fusiform or practically fusiform and the obliterative operation is imperative. If the groove is wide and satisfactory in character, the aneurysm is sacculated and *may* be suited to a reconstructive

operation. If only one opening is present in the sac wall, the aneurysm is sacculated and a reconstructive operation is usually indicated. On opening the sac one may find it to be a false aneurysm; if this is the case, find the opening

FIG. 989.—(*Matas.*)

FIG. 990.—(*Matas.*)

FIG. 991.—(*Matas.*)

FIG. 992.—(*Matas.*)

into the artery and close it by suture or ligate the vessel, unless the false aneurysm is secondary to the rupture of a true one, when one must treat the true aneurysm after clearing out its contents. The sac of a false aneurysm should be treated in the same fashion as that of a true one.

Step 3.—The aneurysm is "fusiform" (Fig. 989). With sutures of catgut on a curved needle (without cutting edges) close all the orifices entering the sac. With a similar suture (continuous), inserted in the Lembert fashion, obliterate the deeper portions of the sac, so that all the stitches closing the orifices are hidden (Fig. 990). Turn the flaps of skin plus sac wall inwards and fix them by sutures as in Figs. 991 and 992. Remove the elastic constrictor. Apply dressings. It is of prime importance not to separate the sac from its surroundings, as its walls are poorly nourished at best, and sloughing is to be avoided. Instead of inverting the skin and part of the sac, the author has excised some of the excess of sac wall and obliterated the rest of the cavity of the sac by means of several rows of continuous Lembert-like sutures of catgut and closed the superficial wound by a separate line of stitches.

In a few cases the walls of the aneurysm are so thick and stiff that it is impossible to bring them together with sutures. In these cases C. H. Mayo has operated as follows: Occlude all the vessels entering or leaving the sac by surrounding each with a purse-string suture of catgut. Very moderate tension on these sutures suffices. Next place a layer of iodoform gauze over the bottom of the sac and fix it in place by a continuous suture of catgut. In the same manner fix layer upon layer of the gauze in place, bringing the end of each piece of gauze out of the wound. Close the skin wound except where the gauze protrudes. Leave the gauze *in situ* until the catgut is absorbed. The cavity soon closes satisfactorily. E. M. Anderson (Am. Jour. of Surg., June, 1919) by mistake widely opened an aneurism thinking it was a psoas abscess. Packing with six yards of gauze led to cure. In another patient with subclavian aneurism similar treatment was successful. The gauze packs are to be removed gradually as they loosen after the formation of granulation tissue. The first of the gauze may be removed in about two weeks, the deepest packs may be left as long as four weeks.

Abbe's case of obliterative aneurysmorrhaphy ("Annals of Surg.," July, 1908, p. 12) for gluteal aneurysm is very instructive. "A young Russian of twenty-four years had been developing for three months right sciatic neuralgia with disability in walking and some swelling of his foot. A pulsating tumor of the right gluteal region prevented his lying on that side also. The man had never had syphilis, but acknowledged gonorrhea. His heart showed a blowing aortic murmur. Examination showed a spherical, pulsating tumor, three inches in diameter, beneath the gluteus muscle at the sciatic notch, where its pressure had caught the sciatic nerve, and held it tightly against the bone—hence the neuralgia.

"It was a particularly good case for operation by the plastic method, because ligation of the internal iliac, while it would temporarily arrest the current would allow free anastomosis and possible return; meanwhile leaving the distended sac to continue sciatic pressure.

"On May 21, 1906, I opened the iliac fossa and threw a temporary silk ligature about the internal iliac artery, which was held as loop by my assistant, Dr. Schley, who drew it up against his index finger-tip, so as to avoid crushing [illegible] ligation. This [illegible]ion at once stopped pulsation in the tumor. [illegible] incised over the t[illegible]parated the gluteus. The sac was well

distended and easily isolated. Its neck filled the uppermost corner of the sciatic notch. On compression, after the pulsation had been stopped from above, it emptied, and quickly filled again. By inference, this must have been by anastomosis, as the iliac artery was quite occluded by the silk loop.

"Seeing no way to keep it entirely empty; I ventured to cut it freely open, and relied on instant internal pressure to stop loss of blood. I first plugged the opening of the gluteal artery with my index finger-tip, and found no other bleeding occurred. I was then able to dry its walls and see that they were firm, with good serous lining. On releasing my finger pressure ever so little, a sharp flow of blood followed, but not in pulsating current. I now began a continuous suture of the internal wall, with fine chromicized catgut, first fixing it by a knot just above my finger-tip. The next stitches were placed so as to catch in the sac wall, on both sides of my finger-tip, which I drew back as I quickly tightened them, thus sealing up the deepest part of the funnel-shaped cavity. After placing the first four deep stitches there was no bleeding, and I leisurely secured one wall against the other by continuous back and forth suturing, with the same thread. I even continued this until I had obliterated the entire sac, and closed the superstructures, with no additional knot. The silk thread was removed from the iliac. The wound was bloodless. The patient made an immediate recovery. The patient had no recurrence of tumor or sciatic pain up to three months after operation."

RECONSTRUCTIVE ENDO-ANEURYSMORRHAPHY (MATAS)

Steps 1 and 2 are the same as in the preceding operation.

(*a*) The aneurysm is sacciform. Only one well-defined opening is visible entering the sac. Close the opening by a line of sutures introduced in the Lembert fashion. These sutures should be of No. 1 silk impregnated with sterile vaseline and should be introduced by means of the finest possible intestinal needles. (Curved needles will be most convenient.) Before suturing, the parts to be sutured should be douched with salt solution or coated with vaseline (see Arteriorrhaphy). Obliterate the sac as in the obliterative operation.

Matas originally closed the communication between the artery and the sac with catgut, but the method described above is better.

The author operated (using catgut throughout) in one case, and while the aneurysm was cured he feels sure that the reconstruction of the artery must have failed as the catgut stitches are well calculated to cause obliteration of the vessel. Even if the artery ultimately becomes obliterated, it probably closes somewhat slowly and gives time for collateral circulation to become established.

(*b*) The aneurysm is sacciform, but there are apparently two openings into the sac connected by a sufficiently wide groove of healthy arterial wall. After douching the groove and the openings with salt solution and smearing them with vaseline (see Arteriorrhaphy), pass the ends of a piece of a soft rubber catheter into the two arterial openings and let the tube lie in the groove (Figs. 993 and 994). Have a loop of thread round the catheter with which to extract it when it has served its purpose. With very fine silk sutures (vaselined) on fine round needles stitch the sac on one edge of the groove (using healthy tissue) to the corresponding edge on the other side of the groove, over the catheter. Extract

the catheter and tighten the sutures. If an extra stitch seems indicated, insert such. Slowly remove the elastic constrictor (or temporary hemostatic agent). If any bleeding takes place at the line of suture, stop it by one or more extra sutures. Obliterate the rest of the sac as in the obliterative operation.

W. J. Frick and the author have each performed this operation using catgut as recommended originally by Matas instead of vaselined silk, in both cases the aneurysm was cured, but as the ankle pulse was not to be felt either before or after the operation there is no proof as to the success of the reconstruction of the artery. Personally, the author thinks that obliteration of the vessel probably occurred due to the kind of catgut used.

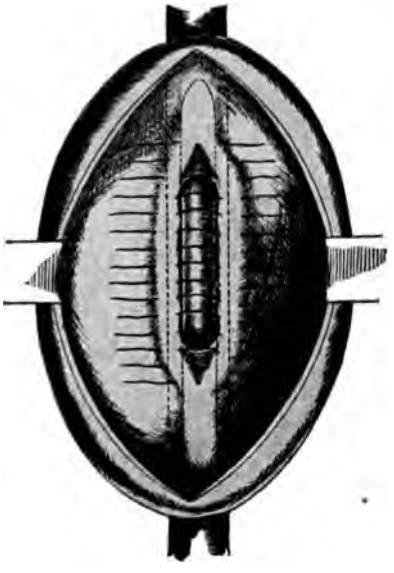


FIG. 993.—(*Matas.*)

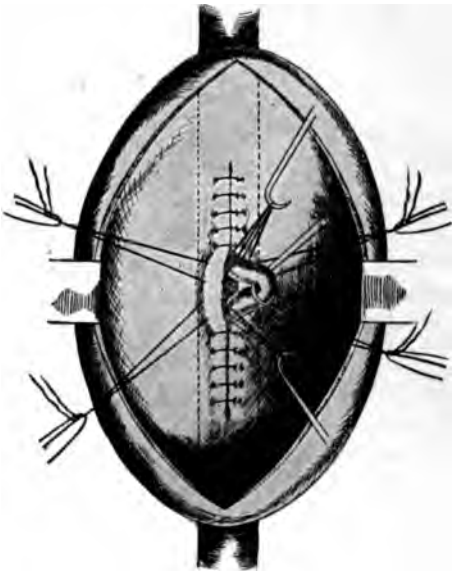


FIG. 994.—(*Matas.*)

When applicable, the author believes one or other of the methods of Matas superior to all others in the treatment of aneurysm.

Macewen's Operation.—In cases of otherwise inoperable aneurysm Macewen has endeavored (successfully in some cases) to assist nature in forming a "white blood-clot" on the walls of the sac. The operation consists in pushing long, delicate, finely polished steel pins, like ladies' hat pins, into the sac and through its cavity so as to touch but not penetrate the inner surface of the sac on the opposite side. The current of blood acting on the pins, makes them quiver and continuously scratch the intima. On the scratched intima a firm white blood-clot is deposited which may become organized and result in a cure. Macewen recommends that the scarification be carried out for about ten minutes at one spot and then that the pin be partly withdrawn and applied at another point. In large aneurysms several pins may be inserted at the same time. "The action of this procedure is slow; sometimes it may be weeks before any noticeable thickening of the coats is made out; sometimes, on the other hand, it may be much more rapid. The pins may be introduced on several occasions;

it is well to leave an interval of a week to a fortnight between each introduction" (Cheyne and Burghard).

Aneurysm of the Arch of the Aorta (Fibrous 'cerclage').—Tuffier (Bul. et Mem. Soc. de Chir de Paris, Feb. 3, 1920, p. 166) by transverse section of the sternum exposed an aneurysm of the ascending portion of the arch of the aorta. The aneurysm was situated one finger's breadth above the origin of the aorta, was about 5 cm. (2 in.) long and at its site the aorta was doubled in volume. A long strip of fascia lata about two finger's breadth wide, was wrapped around the vessel in two layers, each fixed separately by a few silk sutures. Enough tension was exerted to slightly narrow the caliber of the aorta. The result was good. After 5 years the patient was examined and the aorta was found dilated on the left side but no grave functional troubles had arisen.

ARTERIO-VENOUS ANEURYSM

When important vessels are the site of arterio-venous aneurysm and when the lesion and circumstances permit, it is most proper to endeavour to destroy the communication between the vessels and to repair the vessels themselves. For this work the lessons taught by the laboratory must be fully and judiciously utilized. Where it is impossible to gain direct access to the lesion one may incise the vein and through it may close the arterio-venous fistula, subsequently suturing the incision made in the vein (Matas). This has been done successfully.

The classical method of operating on arterio-venous aneurysm, whether aneurysmal varix or varicose aneurysm, is by ligation of the afferent and efferent vessels with or without excision of the sac. It has been strongly urged that when it is possible to save one of the vessels constituting the aneurysm the vein should be preserved rather than the artery so as to avoid dangers of gangrene. Makins (Gunshot Injuries to the Blood Vessels, 1919, p. 101) has proved that there is much less danger of gangrene developing if the aneurysm is excised than if the afferent artery is alone tied. In many cases of vascular wounds it is safest to ligate *both* the artery and the neighboring vein. Makins writes "The result of the combined procedure is to maintain within the limb for a longer period the smaller amount of blood supplied by the collateral arterial circulation, and hence to improve the conditions necessary for the preservation of the vitality of the limb." In support of these views Makins quotes Oppel's six cases of ligation of the popliteal vein for the treatment of senile gangrene of the foot, in all of which the extremities were seen to recover not only their warmth and color without the development of œdema, but also a certain degree of hyperemia of the feet and toes.

Methods of Operating on Arterio-venous Aneurysm Other than by Simple Ligation.—If possible use provisional hemostasis by means of an elastic constrictor; if this is not possible expose the afferent and efferent vessels at an early stage of the operation and control them as in arteriorrhaphy. Incise the sac if one is present or separate the adherent artery and vein one from the other. If the wounds in the artery and vein can be closed without too much narrowing of their lumen, do so in the Carrel fashion. Remove the clamps or constrictors and close the wound.

If the artery is completely divided or nearly so, make an end-to-end arterial anastomosis either by Murphy's invagination method (the pioneer operation) or by Carrel's method. In one case of popliteal arterio-venous aneurysm E. Lexer excised the injured portions of the artery and vein, and although there was 5 cm. (2 inches) of separation betwen the vessel ends when the knee was extended, he was able to unite artery to artery and vein to vein with Payr's prosthesis, when the knee was flexed. After six weeks extension of the knee was possible.

Stich ("Deutsche Zeitsch. für Chir.," xcv, 577) extirpated an arterio-venous popliteal aneurysm and united the divided artery by Carrel's circular suture. The operation was performed as follows: Four-inch incision on inner side of thigh immediately above the knee-joint. Exposure and isolation of the aneurysmal tumor which was a sacciform dilatation of the popliteal artery. The vein was torn during an attempt to separate it; as a result it was necessary to resect 1½ inches of the vein at the level of the aneurysm. The artery communicated with both the vein and the aneurysm sac. Suture of both openings in the artery would have produced too much stenosis, so Stich resected a short segment of the artery and united its divided ends by Carrel's method. Slight flexion of the knee permitted easy approximation of the ends of the artery. During the after-treatment the knee was kept slightly flexed. Three months after operation the patient was found to be well.

When, after separation of the unnatural anastomosis between artery and vein, so much tissue is lost that direct end-to-end anastomosis is impossible, a segment of another and unimportant vessel may be implanted. E. Lexer has used a segment of the long saphenous vein to replace a segment of the axillary artery.

Transvenous aneurysmorrhaphy suitable in cases of aneurysmal varix where the circulation can be controlled during the operation by a tourniquet. (Matas, Med. News, Oct. 27, 1888. Annals Surg., Feb., 1903. Bickham, Annals Surg., May, 1904. William Pearson, Brit. Med. Jour., June 14, 1919.)

Step 1.—By suitable incision expose the vessels.

Step 2.—Open the vein longitudinally opposite the stoma. Gently irrigate with salt solution to get rid of blood which may be present. Never wipe the intima with gauze, but remove the excess fluid by the gentlest of mopping. Smear the interior of the vessels with vaseline.

Step 3.—Immediately above the stoma unite the vein to the artery by a stitch of fine vaselinized silk which penetrates the fibrous tissue around the stoma, but does not penetrate the vessels. Tie the suture. At a point close to one end of the stoma, pass the needle obliquely through the wall of the vein (from without inwards) and with the same suture close the opening (the stoma) between the artery and vein exactly as in Matas' reconstructive endo-aneurysmorrhaphy. When the closure is complete pass the needle obliquely from within outwards through the wall of the vein near the lower end of the stoma [redacted] secure it outside the vessels in a manner similar to that used in beginning [redacted]itch.

[redacted]—Close the opening in the vein by Carrel's suture.

Gregoire gives a good review of the treatment of arterio-venous aneurysm in a paper read before the Societé de Chir de Paris, March, 1919 (Am. Jour. of Surg., Oct., 1919). In his opinion operation should *not* be performed less than six weeks after the causal injury. Matas' paper on arterio-venous aneurysm (Annals of Surg., April, 1920) is a mine of information and is invaluable.

CHAPTER LXIII

LIGATION OF ARTERIES IN CONTINUITY

In the succeeding pages the ligation of but a few of the principal arteries is described. These are the vessels which occasionally call for ligation in actual practice. At the present day operations for the tying of other vessels are almost exclusively valuable as anatomic exercise and hence have no place in this work.

The above remarks are applicable to the surgery of arteries during times of Peace, but in War Surgery and even in some peace time accidents there is so much disintegration of tissue, the normal anatomy is so distorted and there is so much doubt as to what vessel is injured that the classical methods of exposure are inefficacious even if the surgeon remembers them during an emergency. For a few of the arteries the methods of exposure worked out by Fiotte and Delmas (Decouverte des Vaisseaux profonds, Voies d'accès larges. Masson et Cie.) will be given.

A few general remarks on methods of ligating arteries:

1. Refresh the memory regarding the anatomic details of the region to be invaded.

2. Place the limb in good position and mark on it the line of the artery. A line of scratches or very shallow incisions is the best mark to make.

3. Steady the skin with the left hand. This is important, as in making the incision the skin will slide on the deep structures, and the "marked line" will no longer correspond to the artery. Make a clean incision through the skin and superficial fascia. The incision usually must be 2½ to 3 inches long.

Precision in work is required, hence very short incisions are objectionable. Free access is absolutely requisite.

4. Retract or doubly ligate and divide all vessels which come in the way. Pick up thin layers of the deep structures in forceps on each side of the line of incision and thus elevate a *transverse* fold of the tissue which becomes emphysematous and can be safely cut. Continue this proceeding, dividing the tissues layer by layer until the artery in its sheath is reached. When penetrating the deep parts through intermuscular septa the dissection may be accomplished with the handle of the scalpel.

As the wound is deepened its edges must be held apart by blunt retractors; but the retraction must be made with care, otherwise the depth of the wound will be distorted and the line of the artery lost. The deep structures must be divided as extensively as the skin or nearly so.

5. The artery being reached must be distinguished from neighboring veins and nerves. The nerves appear as white, firm, solid cords. The veins when empty look like thin fibrous sheets, when full they are soft, easily compressed,

and when compressed they fill up on the distal side. The veins are larger than and often overlap the arteries, and through them the pulsation of the artery may be felt. Occasionally nerves may transmit pulsation in a most deceiving manner from the artery to the palpating finger. Arteries feel to the finger like fairly firm tubes, and they pulsate. This pulsation may, however, be feeble under certain circumstances or, as already noted, it may be transmitted to nerves, etc., and thus error may arise. During every step of the operation from skin incision to exposure of the vessel be careful to recognize every anatomic guide

FIG. 995.—Incision of arterial sheath. (*Esmarch and Kowalzig.*)

either by eyesight or by touch. Farabeuf, speaking of the importance of touch, says the surgeon should, in the dissecting-room, "accustom himself to ligate certain arteries with his eyes in the air and his fingers in the wound as soon as the superficial incision has been made." Accurate hemostasis and a dry wound are of much importance.

6. The artery lies in a fibrous sheath much as a tendon does. This sheath must be opened. When the fibrous sheath has been exposed, with dissecting forceps pick up a transverse fold of it (Fig. 995). If the forceps are applied from side to side so as to pick up a longitudinal fold of the sheath they may include in their bite a portion of the wall of the vessel.

Apply a scalpel with its flat surface to the vessel and cut a notch in the elevated fold of sheath, parallel to the vessel. Lay aside the knife. Do not let loose the forceps. With the blunt point of a probe, director, or aneurysm needle insinuated through the opening in the sheath separate the sheath from the vessel for a short distance and catch the edges of the wound in the sheath with fine-pointed hemostasis forceps; unless this is done it may be difficult to find the opening in the sheath again. Pass the aneurysm needle between the sheath and the artery half way round the vessel in one direction, and then do the same in the opposite direction. In this manner about ¼ inch of the artery is completely separated from its sheath. From the vein side of the artery pass the aneurysm needle completely round the vessel under the sheath. When the eye of the instrument protrudes at the opposite side of the vessel, thread it; withdraw the needle and thus place the ligature in

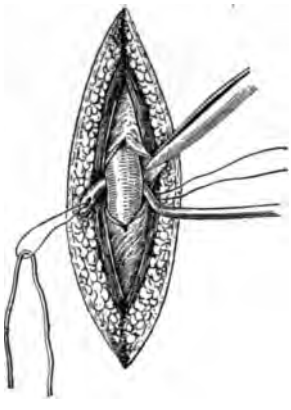


FIG. 996.

n. If the needle is armed with a stout ligature before being passed the atly impedes the manœuvre. On the other hand, it is often difficult

to thread the needle after it has been passed. To avoid these difficulties the author arms the needle with a fine thread of silk or hemp, passes the needle thus armed round the vessel, picks up the loop of the fine thread, withdraws the needle, passes a stout ligature through the loop, withdraws the loop, and so brings the ligature into position (Fig. 996). If too much of the artery is separated from its sheath nutrition is impaired and the vessel may necrose.

7. The ligature may be of catgut, silk, hemp, tendon, ox-aorta, etc., according to the whim of the operator. Tie the ligature in a reef knot. If catgut is used make three ties. Some surgeons recommend that the ligature be tied tightly enough to rupture the intima. This is not necessary, all that is requisite is to have the lumen obliterated and the inner surfaces of the intima in contact.

8. Close the wound accurately. Apply dressings. Keep the limb at rest, elevated and warm.

LIGATION OF THE COMMON CAROTID ARTERY

(A) Ligation at the site of election, *i.e.*, above the omo-hyoid muscle in the carotid triangle.

Place the patient on his back with a firm pillow under the shoulder and neck with his chin directed upwards and towards the opposite side (the head moderately extended and rotated).

Step 1.—**Method A.**—Make a three-inch incision along the anterior margin of the sterno-mastoid having its mid-point opposite the cricoid cartilage. Divide the subcutaneous tissue and the platysma throughout the length of the wound. Do not unnecessarily injure the superfical veins.

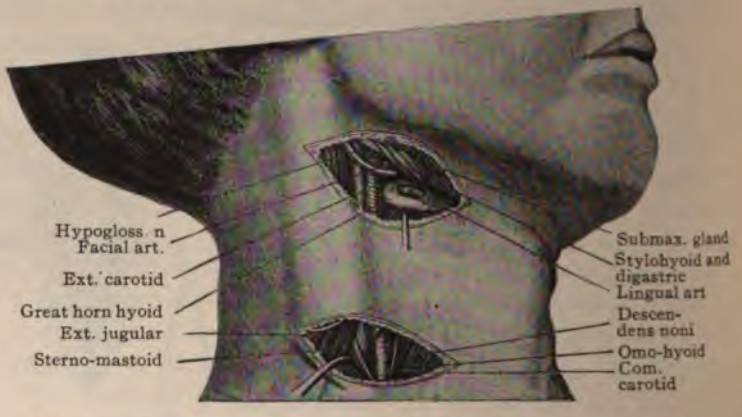


FIG. 997.—Exposure of common carotid and lingual arteries. (*Kocher.*)

Method B.—Kocher's Incision.—At the level of the cricoid cartilage make a three-inch horizontal incision through the skin and platysma. The incision follows the direction of the folds in the neck and is slightly oblique from above downwards and inwards (Fig. 997).

The centre of the incision must correspond to the anterior edge of the sterno-mastoid. Divide the fascia covering the sterno mastoid. Retract the edges of the wound.

ep 2.—Retract the sterno-mastoid outwards. Recognize the anterior of the omo-hyoid. Palpate for the carotid tubercle (transverse process, cervical vertebra) at the angle formed by the crossing of the sterno-mastoid he omo-hyoid. The artery crosses the tubercle. Observe a nerve running wards throughout the wound (descendens noni); it lies directly on the h of the carotid vessels. Open the common sheath of the carotid vessels e inner side of the descendens noni nerve, and retract outwards the nerve the corresponding portion of the sheath (Fig. 998).

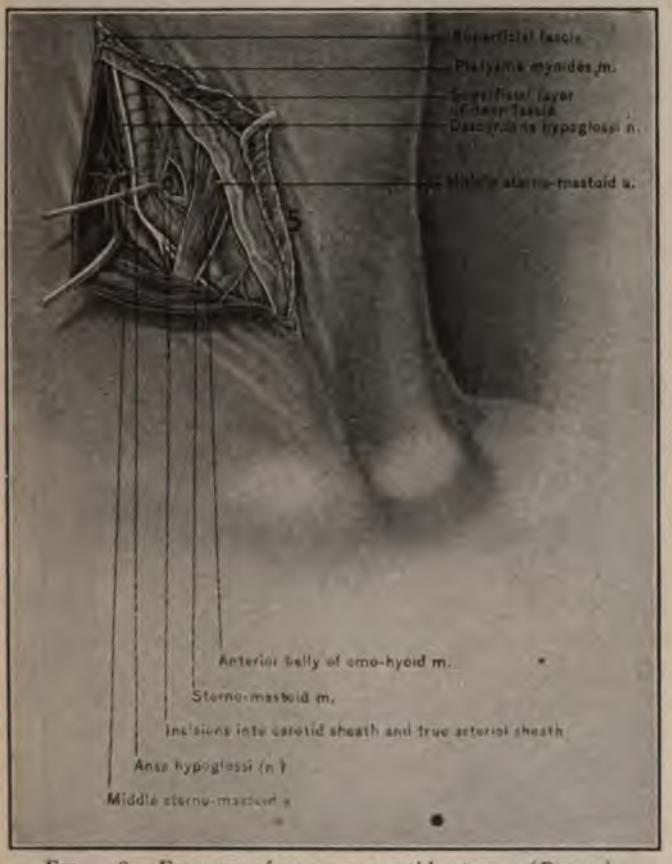


FIG. 998.—Exposure of common carotid artery. (*Deaver.*)

ep 3.—Note the internal jugular vein lying to the outer side of, and some- overlapping the artery. The vagus nerve lies behind and between the r and vein. Pass an aneurysm needle round the artery from the outer nwards. Beware of including the vagus nerve in the ligature.

LIGATION BELOW THE OMO-HYOID MUSCLE

) Here the artery is deeply seated and is difficult to expose.

ep 1.—**Method A.—Kocher's Incision.**

ethod B.—Make a 3-inch incision having its lowest end ¾ inch external e sterno-clavicular articulation. This incision is parallel to the sterno- id and lies between its sternal and clavicular portions.

Method C.—Make a 3-inch incision along the anterior margin of the ster mastoid from the level of the cricoid cartilage downwards.

Step 2.—**Method A.**—Incision (B) has been made. Divide the platys throughout the length of the wound. Penetrate between the two heads of t sterno-mastoid, until the internal jugular vein is seen. Retract outwar the vein and the clavicular portion of the sterno-mastoid. Retract inwards t

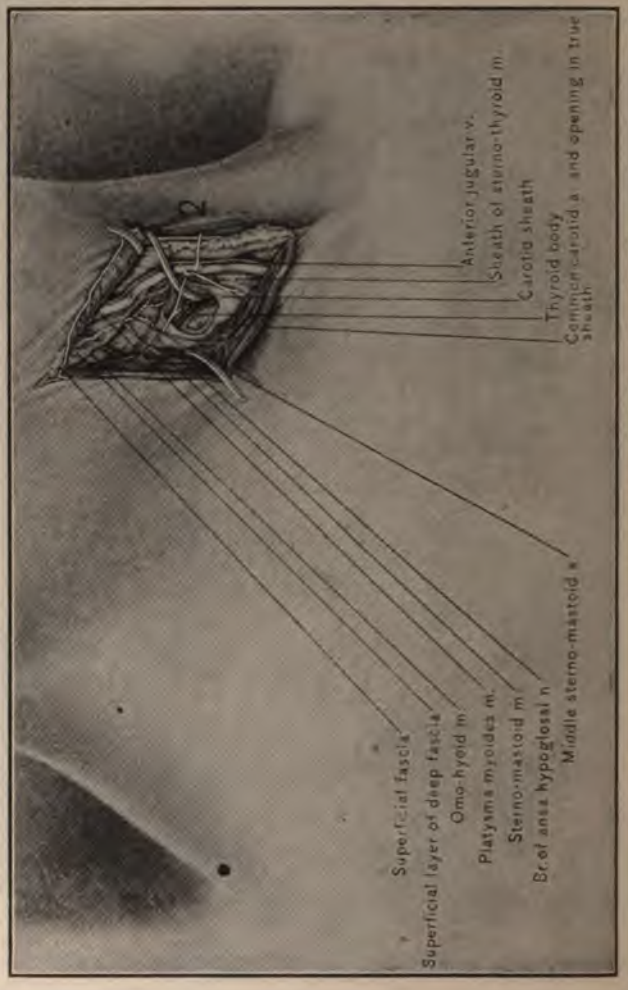


FIG. 999.—Exposure of common carotid below omo-hyoid. (*Deaver.*)

sternal portion of the sterno-mastoid and with it the sterno-hyoid and stern thyroid muscles. The vagus lies to the inner side of the vein, the carotid arte lies somewhat more internal and deeper, under the vein (Fig. 999).

Method B.—Incision (A) or (C) has been made. Divide the deep fas along the anterior edge of the sterno-mastoid. Expose the sterno-hyoid a sterno-thyroid muscles. Retract the latter muscles inwards and the forn outwards. This exposes the carotid sheath. The descendens noni nerv not seen on the front of the sheath in this region (Da Costa). Feel the car

tubercle in the upper part of the wound. As the artery crosses the tubercle it is a valuable landmark.

During the exposure of the carotid sheath a number of veins may require ligation and division.

Step 3.—Open the sheath on its inner side, clear the vessel, and pass the aneurysm needle around it from without inwards, carefully avoiding the vagus nerve.

Remarks.—Ligation of the common carotid may be indicated in cases of wounds, aneurysm, malignant neoplasms (in order to starve the growths), and in hydrocephalus.

Cerebral disturbances frequently follow ligation of the common carotid. These accidents have become less frequent. LeFort's statistics show 45 per cent.; Siegrist's 38 per cent.; Jordan accepts 25 per cent. as being correct; De Fourmestraux (French Congress of Surg., 1908) has experienced the accident in 21 per cent. of his personal cases, while in such operations as for exophthalmos that surgeon's death rate fell to 5 or 6 per cent. De Fourmestraux thinks the cerebral disturbances result from ascending thrombosis due to some trifling infection at the point of ligation. Marquis (Soc. de chir., March 5, 1918) reported 10 cases of traumatic jugulo-carotid aneurisms in which he had tied the common or internal carotid 20 days or more after injury without any cerebral symptoms developing while in 5 cases operated on earlier such symptoms developed. Aumont (La Pr. Med., Feb. 10, 1919) was compelled to operate soon after injury in 2 cases both of which died but without any cerebral complications.

Such being the case, the surgeon is always in doubt whether the patient will come out of the anesthesia, and if he does whether he will exhibit hemiplegia or progressive cerebral softening. In view of these difficulties Jordan recommends partial constriction of the artery for about forty-eight hours before definite ligation. From experiments Jordan finds that it is possible to apply a tape or coarse catgut ligature around the vessel sufficiently firmly to stop the peripheral pulse but sufficiently gently not to injure the intima. This constriction can be kept up for two days without coagulation taking place, and when the constrictor is removed the circulation soon becomes normal again. The preliminary tentative ligation must be accomplished under local anesthesia to permit of immediate observation of any cerebral symptoms which may develop. If the constrictor causes disturbance it may be loosened or removed. By gradual increase of constriction it may be possible to increase collateral circulation. If no objectionable symptoms develop, the ligation may be made complete and permanent.

Matas attains the same ends by bending a narrow strip of metal around the vessel with pressure sufficient to stop the blood current but insufficient to injure the vessel wall. This metal strip is buried; if no symptoms develop it is left *in situ;* if symptoms develop the wound is reopened and the metal removed.

Hydrocephalic children bear ligation of the common carotid well. In these cases both arteries must be tied, but ten days must elapse between the operations (Ballance).

Ransohoff ("Surg., Gyn., Obstet.," August, 1906) advocates ligation of the

common carotid, external carotid, and superior thyroid arteries in cases of pulsating exophthalmos.

Instead of permanently occluding the common carotid, temporary occlusion may be employed to pevent hemorrhage during various operations. For this purpose Fowler threw a tape around the vessel, securing the tape by forceps, while Crile successfully uses his special forceps.

LIGATION OF INTERNAL JUGULAR VEIN

Ligation of the vein may be necessary in cases of sigmoid sinus thrombosis The operation is practically the same as for ligation of the carotid. Particular care must be exercised in passing the ligature around the vein, as its walls are very thin and its size varies greatly during expiration and inspiration.

LIGATION OF THE EXTERNAL CAROTID ARTERY

Position of patient as in ligation of the common carotid.

Method A.—*Step* 1.—Make an incision about 2½ to 3 inches in length along the anterior margin of the sterno-mastoid. The centre of the incision must be opposite the greater horn of the hyoid bone. Divide the platysma and

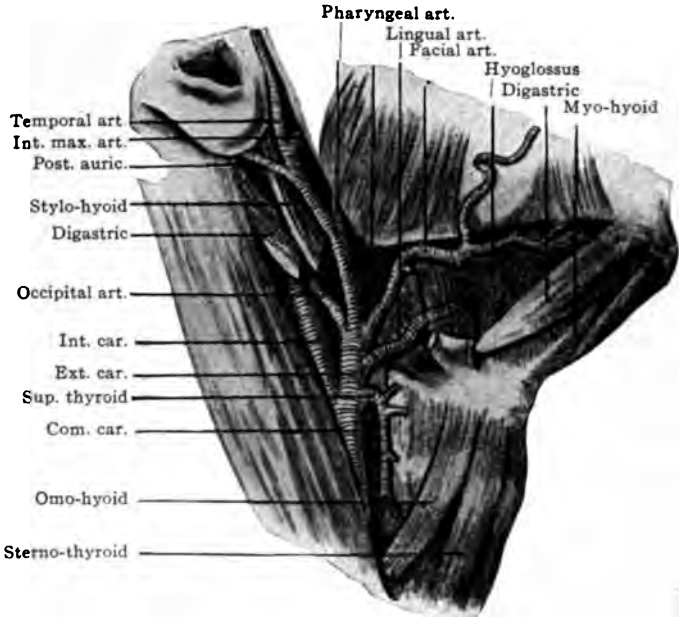


FIG. 1000.—(*Esmarch.*)

the deep fascia (attached to the sterno-mastoid) throughout the length of the wound. Retract the sterno-mastoid outwards.

Step 2.—Find the posterior belly of the digastric muscle in the upper part of the wound (Fig. 1000). Find the hypoglo[illegible] a little below the digastric (Fig. 1001). Retract these structures up[illegible]d injuring the facial and superior thyroid veins.

Note the tip of the great cornu of the hyoid bone and expose the artery opposite this guide. As the internal carotid has been mistaken for the external, it is very wise to demonstrate one of the branches of the external carotid before passing a ligature around the vessel.

Step 3.—Pass a ligature around the vessel from without inwards, avoiding the vein which lies to the outer side of, and frequently overlaps the vessel, and also avoiding the superior laryngeal nerve which runs behind it.

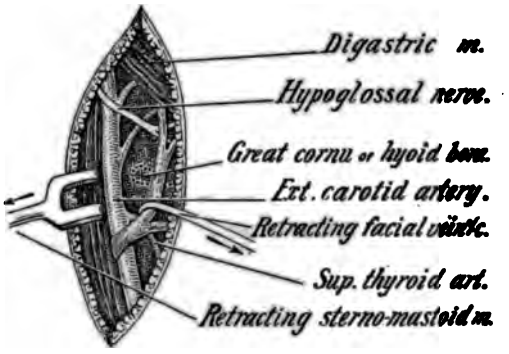


FIG. 1001.—Exposure of right external carotid.

W. P. Nicolson (Surg., Gyn. and Obst., July, 1919) writes: "A skin incision 4 inches in length is usually advised but an opening of from 1 to 1½ inches, with its center opposite the upper border of the thyroid cartilage is usually ample. The incision should go through the skin and platysma muscle. After the deep fascia has been opened, I know of no operation in which the finger is more useful. With the index-finger the way can be rapidly torn down to the vessel, without damaging any of the structures. We are often told that the guide to the vessel is feeling the pulsation with the finger, but the rapid breathing of the patient makes this very unreliable. It is a useful thing to remember that the common carotid always has a bulbous swelling just as it bifurcates, and this I have found a valuable guide. The vessel is recognized by its yellowish white color. I do not find any distinct sheath at this point, though we are told to pick it up and open it. My rule is to pick my way down to the bare artery with a tissue forcep and the point of the finger. . . I take issue with what is usually described as the point of election, namely, between the facial and lingual branches. The point of election with me is the immediate crotch of the vessel, for thus no space is left in which thrombus can form. I have never seen any allusion to the relation of the anatomy or surgery of this vessel to the dense connective tissue, the remains of the carotid gland which binds the trunks together. At this point, the space between the vessels is simply an indistinct groove. The aneurism needle is passed from within outward, and when it comes against this tissue, it appears as if coming directly through the walls of the artery. I rub the point through with the finger or some instrument, and thread it, and withdraw the ligature with it. This seems to work more satisfactorily than when it is threaded beforehand.

"A practical point of extreme value is to have the anæsthetist place his

finger upon the temporal artery, and the operator either cross or pull upon the ligature, to see that it stops the circulation in the temporal. I know this is important, because once when I did not take this precaution, I tied the internal by mistake."

Method B.—Kocher's Incision.—*Step* 1.—Choose a point on the anterior margin of the sterno-mastoid muscle, one finger's breadth below the angle of the jaw. Make a slightly oblique incision horizontal having its centre at the above point (Fig. 1002). After exposing the anterior edge of the sterno-mastoid the operation becomes practically the same as Method A.

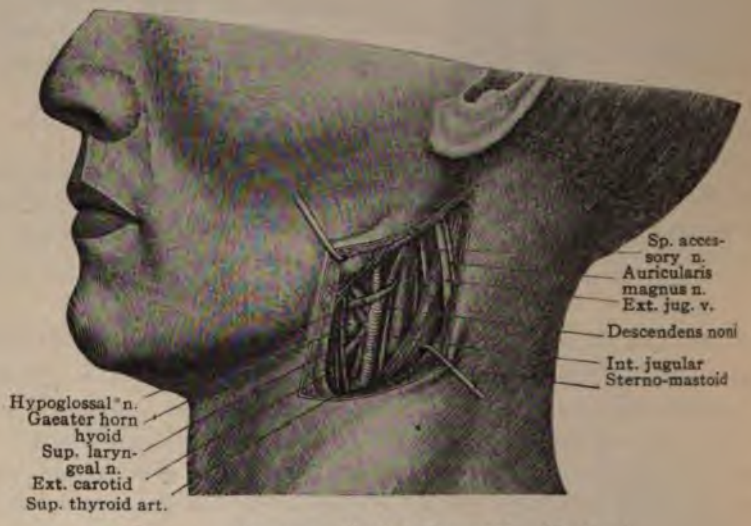


FIG. 1002.—Exposure of external carotid. (*Kocher.*)

Indications.—(*a*) Hemorrhage from wounds of branches.

(*b*) As a preliminary step in the removal of some tumors, *e.g.*, of the retro-pharyngeal space.

(*c*) Aneurysm.

(*d*) Occasionally to prevent hemorrhage from the middle meningeal artery during operations on the Gasserian ganglion.

Remarks.—Hearn ligates the external carotid as a preliminary to excision of the superior maxilla for malignant disease, and states that in doing so he exposes some enlarged lymph nodes which would otherwise escape notice. Armstrong ligates both external carotids while excising the lymphatic areas before removing the cancerous tongue. W. P. Nicolson strongly recommends single (if necessary double) ligation immediately before undertaking any facial or maxillary operation which would otherwise be dangerously bloody. He especially favors ligation to control the middle meningeal artery while removing the Gasserian ganglion. Matas thinks it important to place the ligature well above the bifurcation of the common carotid to avoid the danger of cerebral embolism. Nicolson takes exception to this.

Step 1.—Expose the external carotid (see p. 840). The internal, at its origin, lies a little behind and to the outer side of the external carotid.

Step 2.—Gently retract the external carotid inwards. Open the sheath of the internal carotid immediately over the artery. Remember that the artery, the internal jugular vein and the vagus occupy the same sheath, the vein being external and the nerve behind and between the vessels. Pass the aneurysm needle around the artery from without inwards.

Indications.—For intra-cranial aneurysm of vessels other than the meningeal. For hemorrhage, *e.g.*, after tonsillectomy. If the operation seems called for because of hemorrhage after tonsillectomy, expose and apply pressure to the external carotid—if this controls the bleeding it must be from the tonsillar artery and ligation of the internal carotid becomes unjustifiable.

Lingual Artery.—The lingual artery arises from the external carotid at the level of the great horn of the hyoid bone (Fig. 1000). After running a curved course it dips under the hyoglossus muscle and proceeds forwards parallel and close to the greater horn of the hyoid. It is crossed by the digastric and stylohyoid muscles. The hypoglossal nerve runs parallel to the lingual artery, but is more superficial, being separated from it by the hyoglossus muscle.

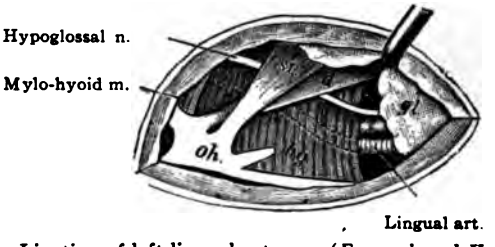


FIG. 1003.—Ligation of left lingual artery. (*Esmarch and Kowalzig.*)
d, Digastric. *Oh*, Great horn hyoid. *hg*, Hyoglossus. *gl*, Salivary gland. *st*, Stylohyoid.

The Operation.—*Step* 1.—**Method A.**—Make an incision parallel to and about 1½ inches above the great horn of the hyoid. Divide the skin and the platysma. Divide the deep fascia. Ligate and divide or retract any veins which come in the way.

Step 2.—Retract the submaxillary gland upwards (Fig. 1003). Expose the posterior belly of the digastric under which lies the hypoglossal nerve. The nerve forms a good guide to the hyoglossus muscle on which it lies. The lingual vein may lie either superficial to the hyoglossus or beneath it along with the artery. Avoid injury to the nerve and vein.

Step 3.—Carefully divide the hyoglossus (on a director) between the hypoglossal nerve and the great horn of the hyoid. This exposes the lingual artery, which is accompanied by a vein or *venæ comites*.

Method B.—Kocher.—*Step* 1.—Make an incision parallel to and immediately above the hyoid bone, from the anterior edge of the sterno-mastoid to

[illegible], and fascia, as if to lay bare the great horn of the hyoid.

The digastric and stylohyoid muscles and the submaxillary gland appear in the upper part of the wound.

Step 2.—Let the assistant exercise vertical pressure on the great horn of the hyoid on the opposite side of the neck; this pushes the bone into the wound. Seize the horn of the hyoid with a hook and pull it up, so that the whole region becomes superficial. Note the fibres of the hyoglossus muscle running upwards and the hypoglossal nerve passing from behind forwards over the muscle.

Step 3.—With utmost care divide the hyoglossus, transversely, immediately above the bulbous end of the great horn of the hyoid. This exposes the artery.

Indications for ligation of the lingual artery:

(1) Preliminary to excision of the tongue. (2) To starve malignant neoplasms in territory supplied by the artery. (3) To stop hemorrhage.

Superior Thyroid Artery.—Kocher's Method.—Ligation of the superior thyroid artery is done at the top of the upper horn of the thyroid gland.

Step 1.—(A) Make an incision parallel to and immediately above the hyoid bone, from the anterior edge of the sterno-mastoid to the body of the hyoid. Divide the skin, platysma, and fascia. Retract the lower edge of the wound strongly downwards.

(B) If the upper horn of the thyroid gland does not extend far up the neck, make the incision ¾ inch lower, corresponding to the upper margin of the thyroid cartilage.

Step 2.—Feel the pulsations of the anterior branch of the artery on the median-anterior side of the upper horn of the thyroid gland beside the larynx. Follow this vessel over the apex of the gland until the main artery is reached.

Step 3.—Ligate the main artery.

The only indication for ligation of the superior thyroid artery is hyperthyroidism. C. H. Mayo, Stamm and others prefer to ligate the upper pole of the thyroid gland, thus tying the branches of the superior thyroid artery in a mass ligature.

LIGATION SUPERIOR POLE OF THYROID

If general anesthesia is to be used administer morphine gr. ⅙ with atropine gr. 1/100 about half an hour before operation.

Step 1.—Make a transverse incision, if possible in a natural crease, two and one-half inches in length, crossing the central part of the thyroid cartilage. The cut divides the skin and platysma and gives access to the gland on both sides.

Step 2.—Retract the inner border of the sterno-mastoid outwards and expose the omo-hyoid. Retract the omo-hyoid upwards and inwards. Under the omo-hyoid lies the upper pole of the thyroid.

Step 3.—Pass a ligature (linen, silk) round the upper pole and tie it (Fig. 1004). If a vein is pierced by the aneurysm needle and causes bleeding pull upon the ligature and pass a second ligature including more tissue. The ligature includes veins, arteries, and gland tissue. There is no danger of injuring the recurrent laryngeal nerve (Mayo, "Annals of Surg.," Dec., 1909).

Stamm and Jacobson strongly recommend ligation of the upper pole in ex-

ıthalmic goitre when more radical operations seem inadvisable. The author ıds the operation by no means difficult.

Inferior Thyroid Artery.—*Step* 1.—Expose the common carotid artery and ternal jugular vein immediately below the tendon of the omo-hyoid. (Do is either through Kocher's incision or through an incision along the inner argin of the sterno-mastoid).

FIG. 1004.—Ligation of superior pole of thyroid. (*Mayo, Annals of Surgery.*)

Step 2.—Gently retract outwards the carotid packet of vessels and nerves. ıll the tendon of the omo-hyoid upwards. Push the thyroid gland and the ıchea inwards (*i.e.*, towards the opposite side).

Note the transverse process of the sixth cervical vertebra (carotid tubercle). ıpposite this fixed point the inferior thyroid artery may be seen appearing from *behind* the common carotid at about the same level as the omo-hyoid tendon ısses in *front* of that vessel.

Step 3.—Ligate the artery as far from the thyroid gland as possible to avoid injury to the recurrent laryngeal nerve which crosses the artery behind the gland. Be careful not to include in the ligation the middle cervical ganglion or the recurrent laryngeal nerve.

The indications for ligation of the inferior thyroid artery (and for the superior as well) are certain forms of goitre.

Subclavian Artery.—Place the patient on his back, support the shoulders on a pillow so that the head may be extended and turned to the opposite side. Keep the arm well pulled downwards (when possible pass the arm behind the back so as to keep it in proper position).

Step 1.—Choose a point one-half inch above and one inch internal to the middle of the clavicle. Let this point be the centre of a three-inch incision parallel to the clavicle and extending from the Trapezius to the sterno-mastoid.

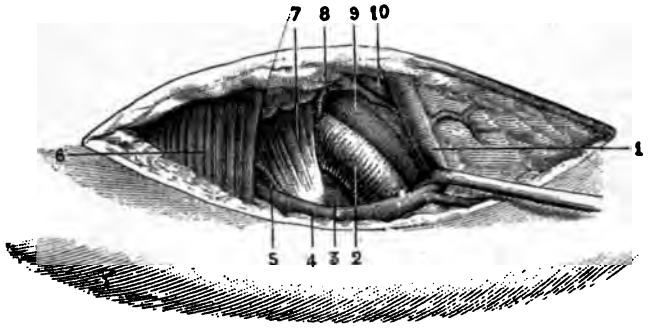


FIG. 1005.—Exposure of subclavian artery. (*Farabeuf.*)

1. Ext. jugular vein—retracted outwards. 2. Artery. 3. First rib. 4. Subclav. vein. 5. Suprascap. art. 6. Sterno-mastoid. 7. Scalenus ant. 8. Transverse cervical art. (post. scapular). 9. Brachial plexus. 10. Omo-hyoid.

In making this incision be careful not to injure the external jugular vein. Divide the skin and the platysma. Retract the external jugular outwards or, if requisite, divide it between two ligatures (Fig. 1005). At this stage difficulties may be encountered due to the venous plexus formed by the transverse cervical and suprascapular veins. If these veins cannot be retracted out of the way, they must be ligated and divided. A dry wound is essential. Divide the deep fascia throughout the extent of the wound.

Step 2.—Note the outer edge of the scalenus anticus muscle. The subclavian vein lies in front of the muscle, the subclavian artery behind it and at a slightly higher level than the vein. Pass the finger along the edge of the muscle until the scalene tubercle on the first rib is felt. The artery lies immediately outside and behind the tubercle. If the omo-hyoid muscle is in the way, retract it upwards.

Step 3.—The lowest cord of the brachial plexus lies immediately above the artery and has been mistaken for it. Systematically expose this nerve cord sufficiently to permit of precise recognition (Treves).

Pass the aneurysm needle around the artery from above downwards and from behind forwards, guiding the needle with the finger and holding the vein out of harm's way. Pull a ligature around the vessel and tie it.

Step 4.—Close the wound

Ligation of the third part of the subclavian artery has alone been described here as the other segments of the vessel are unsuitable for and very rarely require ligation.

Indications.—Axillary aneurysm; axillary hemorrhage; wounds; preliminary to excision of the scapula, or of the entire upper limb, etc., and as treatment for innominate and aortic aneurysms.

Riedel ("Zentralblatt für Chir.," 1907, No. 32) objects to the classical method of ligating the subclavian because the work is not sufficiently guided by the eye. He advocates the following method:

1. Make an incision parallel to the direction of the great vessels of the neck from the level of the transverse process of the fifth cervical vertebra to the middle of the clavicle. Divide the skin and platysma.

2. Doubly ligate and divide the numerous veins which appear; also the transversalis coli artery. The superior nerve trunk soon appears emerging from between the scalenus anticus and medius.

FIG. 1006.—Exposure of axillary artery. (*Farabeuf.*)

3. Work into the groove between the scalenus anticus and medius (distinguished one from another by the emerging nerve trunks). Working downwards, expose the second and third nerve trunks, below the last of which lies the artery. In spite of the depth of the wound, it is *comparatively* easy to sufficiently expose the artery and to ligate it. The whole operation should be performed without introducing the finger into the wound (Riedel) unless gloves are worn.

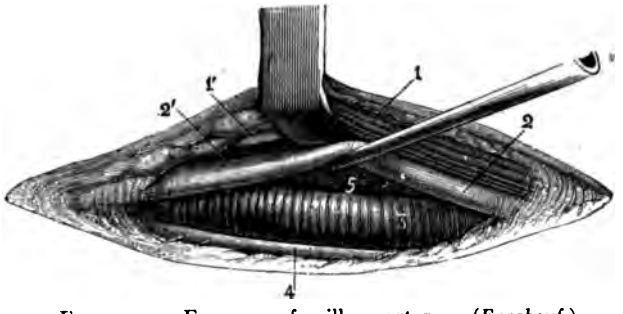


FIG. 1007.—Exposure of axillary artery. (*Farabeuf.*)

The retractor supports the 1st landmark, the coraco-brachialis (1) with the musculo-cutaneous n. (1'); the director supports the 2nd landmark, the median n. (2., 2'). 3 = the art. 4 = int. cutaneous n. 5 = deeply seated small collateral veins.

Axillary Artery.—Farabeuf's Method.—Place the patient on his back at the edge of the table with the arm at right angles to the body. Do *not* either flex or extend the forearm fully.

Step 1.—From the apex of the axilla make a three-inch incision down the arm, immediately behind the anterior wall of the axilla, along the inner and posterior border of the coraco-brachialis (Fig. 1006). As soon as the skin is divided, the posterior edge of the wound retracts and discovers the brachial plexus and axillary vein visible through the aponeurosis (Farabeuf). Elevate

the pectoralis major and under it, *i.e.*, *anterior* to the vessels and nerves, divide the fascia so as to expose the coraco-brachialis muscle.

Step 2.—Recognize the coraco-brachialis muscle (first guide) and free its inner border for a short distance. Relax the muscle by bringing the arm nearer to the patient's side. Retract the muscle forwards with a blunt hook.

Step 3.—With the finger introduced between the coraco-brachialis and the packet of vessels and nerves, push the latter backwards. Very slowly and lightly remove the finger. As this is done one cord escapes from the pocket and slips forwards (*i.e.*, upwards, the patient lying on his back) (Fig. 1007). The cord lies free; it does not perforate the muscle as the musculocutaneous nerve does; it is the median nerve (second guide). Isolate the nerve and retract it with the coraco-brachialis. The next cord felt under the finger is the axillary artery, readily recognized by touch and sight. In order to be sure of tying the artery above where the circumflex branches off, isolate the vessel in the upper part of the wound.

Step 4.—With the finger push the rest of the axillary vessels and nerves backwards (the median nerve is already out of the way). Pass an aneurysm needle around the artery from behind forwards.

Brachial Artery.—The superficial position of the brachial artery is such that its ligation seems easy, but the reverse is the case. Numerous and rather humiliating errors have been reported by good operators. The artery is subject to abnormalities. (*a*) The artery may lie in front of instead of behind the median nerve (one out of six cases). (*b*) The artery may divide high up and thus during the operation two arteries may be met instead of one, each or both of which may require ligation. (*c*) "The artery may be partially covered by a muscular slip given off from the pectoralis major, biceps, coraco-brachialis or brachialis anticus."

The brachial is rarely tied elsewhere than in the middle of the arm.

Step 1.—With the forefinger hold a thread against the skin of the deepest point (the apex) of the axilla. Hold the other end of the thread (drawn tense) on the mid-point of the fold of the elbow. The course of the thread gives the line of the brachial artery.

Step 2.—Along the line of the artery, make a 2½ inch incision through the skin on the inner border of the biceps. Divide the fascia covering the muscle, *thus exposing the muscle itself.*

Step 3.—Free the inner edge of the muscle and very gently retract it outwards; the forearm being slightly flexed to relax the muscle. This exposes the median nerve.

Step 4.—Mobilize the nerve and retract it outwards or inwards as may be most convenient. This exposes the artery accompanied by its two veins.

Step 5.—Open the arterial sheath. Ligate.

Note.—During the operation the arm must be abducted and supported by the elbow or forearm. The arm itself must *not* be directly supported, as pressure on the triceps would alter anatomic relations, thus making exposure of the artery difficult.

Iliac Arteries.—The iliac arteries, especially the internal vessel, are of so much and varied surgical importance that they deserve full consideration.

usual anatomical works do not cast much light on the subject from the eon's standpoint. Quénu and Duval ("Revue de Chirurgie," Nov., 1898) y the anatomy of the iliac arteries in a soul-satisfying and practical manner; ollowing paragraphs are based on their work.

he common iliac arteries bifurcate at the lower level of the fifth lumbar ebra, *i.e.*, at the sacro-vertebral angle, $1\frac{3}{8}$ inches (3.5 c.) from the middle (Fig. 1008). Near their origin the external and internal iliac arteries lie

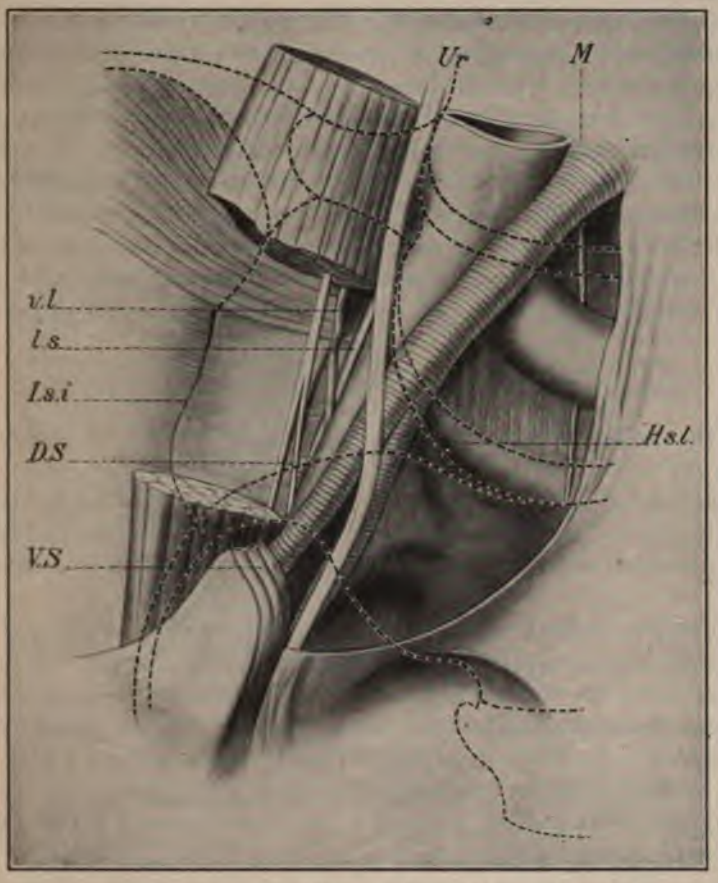


FIG. 1008.—Exposure of iliac arteries. (*Quénu and Duval.*)
M, median line; *Hsl*, int. iliac; *Ur*, ureter; *I.s.i.*, sacro-iliac joint; *D.S.*, brim of pelvis.

together; at the very brim of the true pelvis they are hardly $\frac{1}{4}$ inch apart. ureter crosses the external iliac artery slightly outside and above the inter- liac at the point of election for ligation of the latter, *i.e.*, a little below the of the pelvis. The ureter is fortunately more adherent to the peritoneum to the subjacent structures, and hence is easily retracted along with the oneum. Such are the relations of the iliac arteries near the bifurcation on the side; on the *left* side the surgical anatomy may be the same or very different, rding to the arrangement of the sigmoid or pelvic colon and its meson. et us consider the sigmoid as consisting of two parts, one superior (the

colonic sigmoid), the other inferior (the rectal sigmoid). The meson belonging to the inferior or rectal sigmoid arises *always* in the middle line of the lumbo-sacral region. The meson belonging to the superior or colonic sigmoid has no fixed line of origin. Its lower part is always attached along with the meson of the rectal sigmoid, but its upper part may be attached to the parietes anywhere between the spleen (fœtal type) and the pelvic brim (adult type).

The point of junction of the meson of the two portions of sigmoid constitutes the dome of the intersigmoid fossa, and on the floor of this fossa lie the iliac vessels and the spot where the internal iliac must be tied.

The length of the sigmoid varies greatly and with it the length of the meson. If the sigmoid is long, it can be turned upwards with the whole of its meson in such a manner that the intersigmoid fossa becomes obliterated and the iliac bifurcation is as easily exposed as on the right side of the body. If the sigmoid is short its meson is short likewise; by turning the gut upwards its meson becomes folded on itself; it is impossible to expose the point of union of the superior and inferior portions of the meson; the intersigmoid fossa is a true fossa or tunnel; it is impossible to reach the bifurcation of the iliac artery without going through the meso-sigmoid. This second arrangement of the sigmoid is the rule.

LIGATION OF THE INTERNAL ILIAC ARTERY

(A) **On the Right Side.**—*Step* 1.—Place the patient in the Trendelenburg position (75°).

Method A.—Open the abdomen by a vertical incision either in the middle line or through the rectus muscle reaching from the pubis to near the umbilicus. This more or less median incision is the best if the vessels on both sides are to be tied.

Method B.—Make a vertical incision through the skin and anterior layer of the rectus sheath near the outer edge of the rectus. Either split the rectus muscle or pull it towards the middle line. Incise the posterior layer of rectus sheath and the peritoneum along a line corresponding to the skin incision.

Method C.—Open the belly by the gridiron or muscle-splitting method devised by McBurney for appendicectomy.

Especially in fat patients, method A is the best, as very free access to the vessels is of great value.

Step 2.—Widely retract the edges of the abdominal wound. Push the small intestines out of the way and protect them with pads. Put the index finger on the sacro-lumbar promontory in the middle. Note a point 1⅜ inches (3.5 c.) to the right side at the same level. At this place a pulsating prominence is visible running from above downwards and outwards. This pulsating prominence consists of the common and external iliac arteries. Another prominence (the ureter) can be seen crossing it. Run the finger down the common iliac artery until the bifurcation is reached when pulsation will be felt on both sides of instead of only under the finger.

Step 3.—Make an incision 1½ inches long through the parietal peritoneum, 1⅜ inches to the right of the middle line, parallel to the iliac vessels and having its mid-point opposite the lumbo-sacral prominence. Elevate the edges of this

wound by blunt dissection. The ureter comes away with the outer edge of the wound and is thus lifted out of harm's way. At the upper angle of the peritoneal wound lies the common iliac, at the centre of the wound lies the bifurcation, at the lower angle lie the external and internal iliacs, side by side, still covered by a sheath of fascia.

Step 4.—Incise the fascial sheath *secundum artem*; denude the internal iliac; pass an aneurysm needle from without inwards, closely hugging the artery so as to avoid injury to the external iliac vein, and apply a ligature ¾ inch from the origin of the vessel, *i.e.*, at a point a very little below the brim of the true pelvis. Do not forget that the internal iliac vein lies to the inner side of the artery.

(B) **On the Left Side.**—*Step* 1.—Put in Trendelenburg's position. Open the abdomen either in the middle line or on the *left* side.

Step 2.—(*a*) If the sigmoid is long and provided with a long meson, turn it upwards. This obliterates the intersigmoid fossa and leaves the vessels as well exposed as on the right side. Ligate the vessel in the same manner as on the right side.

FIG. 1009.—Exposure of left iliac artery.

(*b*) If the sigmoid is short and has a short meson it cannot be turned up so as to expose the vessels. Pull the sigmoid downwards so as to spread out its meson. Note the position of the mesenteric vessels in the meson; they must not be injured. At a point 1¾ inches from the middle line on a level with the lumbo-sacral prominence make a vertical incision through the meso-sigmoid, carefully avoiding injury to any of its vessels (Fig. 1009). The middle of this incision corresponds to the lumbo-sacral prominence and its lower end must *not* approach the sigmoid closer than 1¼ inches, lest some of the arterial loops be damaged. If the meson is thick and much infiltrated with fat, it must be penetrated slowly by blunt dissection to avoid injuring the vessels.

When the meso-sigmoid is penetrated as described, the floor of the sigmoid fossa is reached and the rest of the operation becomes the same as on the right side, except that the whole work must be accomplished through the rent or gap made in the meso-colon.

LIGATION OF COMMON ILIAC ARTERY

Sulzenbacher (Zentralbl. für Chir., 1882, No. 23) collected 50 cases among which there were 12 operative successes. The operation is therefore justifiable in certain grave conditions, *e.g.*, of pelvic enchondroma, etc. As the common iliacs are exposed during ligation of the internal iliac vessels the same method may be used. Chalier and Murard (Rev. de Chir., Feb., 1912) advise the following method for ligation either of the right or left vessel.

1. Trendelenburg's position. Median incision from just above the umbilicus to near the pubis.

2. Usually the vessels can be seen and felt so clearly through the peritoneum that the rest of the operation is easy. But (*a*) the transverse portion of the duodenum may occasionally lie so low that it interferes. If this is the case, a cautiously made incision through the peritoneum below the duodenum permits its mobilization exactly as its descending portion may be mobilized in Finney's gastro-duodenostomy or Vautrin's exposure of the retro-duodenal choledochus; (*b*) the mesentery and the pelvic meso-colon, both very vascular and sometimes connected by a mesenteric meso-colic ligament, may interfere. This difficulty may be overcome as follows: Carefully incise the posterior parietal peritoneum vertically in the middle line from a point just above the promontory of the sacrum upwards for 2–3 finger-breadths, *i.e.*, up to or above the bifurcation of the aorta. Care is required so as to avoid injuring the left common iliac vein which crosses the body of the fifth lumbar vertebra obliquely, lying in the crotch of the bifurcating aorta. Through the peritoneal wound, dissecting with a director and blunt forceps, one can raise the peritoneum to right or left and with it the root of the mesentery or of the meso-colon and so expose the artery to be tied. In this operation the ureter is out of danger.

EXTERNAL ILIAC ARTERY

(A) **Transperitoneal Operation.**—The external iliac artery may be exposed high up by the same method as is described for the internal. If it is desired to ligate the vessel at a lower level, it is easy to expose it through the abdomen and place a ligature round it at any level.

(B) **Extra-peritoneal Operation. Cooper's Method.**—*Step* 1.—From a point 1¼ inches external to the pubic spine and about ½ inch above Poupart's ligament make an incision parallel to the ligament to a point opposite the junction of the middle and outer thirds of the ligament. Continue the incision in a curve upwards to a point one inch above and internal to the anterior superior spine. Be sure that the incision is large enough. Divide the abdominal wall layer by layer until subperitoneal fat is reached.

Step 2.—With fingers and gauze push the peritoneum (unopened) upwards and inwards from the iliac vessels. When the vessels are exposed keep the wound open by means of a broad-bladed retractor. Trendelenburg's posture is a great aid.

Step 3.—The external iliac artery will be felt running along the brim of the pelvis near the inner end of the wound. Open the sheath on its outer side to avoid the vein which lies internal to the artery.

Demonstrate and pull aside the genito-crural nerve which lies upon or near the artery. Pass a ligature around the vessel from the inner side. Tie.

Step 4.—Remove the retractor. Permit the peritoneum to fall back into place. Suture the abdominal wall, layer by layer, as in an operation for hernia.

The usual site for ligation is about 1½ inches above Poupart's ligament.

As a means of temporary hemostasis a temporary ligature or tape or Crile's clamp may be applied to any of the iliac vessels. This was the means adopted by Balch to control the circulation when he performed reconstructive aneurysmorrhaphy on the external iliac artery.

LIGATION OF THE COMMON FEMORAL ARTERY

The common femoral may be ligated:

(*a*) As a preliminary step in amputation of the hip.

(*b*) For hemorrhage resulting from wounds or from disease in Scarpa's triangle.

(*c*) For aneurysm of the superficial femoral high up.

Ligation of the external iliac is usually preferable for many reasons. The operation is rarely indicated. The writer once did it successfully for hemorrhage after a high amputation of the thigh where the bleeding-point could not be found.

The dangers of gangrene are of course great. In cases of wounds arterial suture to a large extent takes the place of ligation. The common femoral varies in length, but usually extends for about 1½ inches below Poupart's ligament. The line of the femoral (common and superficial) stretches from a point midway between the anterior superior iliac spine and the middle of the pubis, to the inner margin of the internal condyle of the femur (adductor tubercle).

The Operation.—Semiflex the hip and knee. Abduct and rotate the limb somewhat outwards. Locate the artery by means of its *line* and by palpation. From a point one finger's breadth above Poupart's ligament make a 2½ inch incision downwards along the line of the artery. Divide the skin and superficial fascia. Retract or remove any glands, retract or doubly ligate and divide any veins which may overlie the vessel. Feel for the artery just below Poupart's ligament and divide the deep fascia over it. Avoid injuring the crural branch of the genito-crural nerve which lies over the artery. The femoral vein being on the inner side of the artery, pass the ligature from within outwards. Place the ligature as remote as possible from any branches of the artery.

Ligation of the Superficial Femoral at the Site of Election—Apex of Scarpa's Triangle

The operation may be performed: (*a*) for aneurysm low down on the artery; (*b*) for hemorrhage which cannot be treated by more direct means; (*c*) for elephantiasis. The value of the operation in elephantiasis is very doubtful.

The Operation.—Place the limb as for ligation of the common femoral. [illegible] of the artery is the same as that of the common. From a point about

2½ inches below Poupart's ligament make a three-inch incision downwards along the line of the artery. Divide the skin and superficial fascia. Retract and divide, between ligatures, any superficial veins which may be in the way. Split the deep fascia the whole length of the wound. Note the sartorius crossing the lower part of the wound and retract it outwards. Find the artery by palpation. The long saphenous and the nerve to the vastus internus are in contact with the artery; avoid them. Open the sheath of the artery on its outer side. The vein lies to the inner side of, and behind the artery, therefore pass the aneurysm needle from within outwards and, as the vein has often been damaged during this step, be most careful to hug the artery with the point of the instrument.

Jacobson advises, when the vein is injured, to make pressure on the vein at the lower angle of the wound and then to ligate the artery at a point either above or below the site originally intended, but by no means to persist in attempting to finish the ligation where the accident occurred.

Exposure of femoral vessels in Hunter's canal and incidentally in the upper part of the popliteal space.

Place the patient on his back. Flex hip and knee. Abduct the thigh and *rotate* it outwards as much as possible. Let the surgeon stand facing the inner aspect of the thigh.

Step 1.—Note the prominent cord formed by the tense adductor magnus. Make an incision along the adductor magnus from its insertion upwards for about 6 inches. In the upper part of the wound note the Sartorius and retract it backwards after mobilizing it. With finger and gauze clear away fat and areolar tissue from both the anterior and posterior surfaces of the adductor magnus.

Step 2.—The roof of Hunter's canal now lies exposed. Carefully divide it. The various vessels and especially the internal saphenous nerve, which perforate the roof of the canal are easily seen and avoided. The canal being thus exposed freely and its walls suitably retracted, the vessels are accessible for ligation or for conservative treatment.

Step 3.—As soon as the retractors are removed the deep wound closes naturally. Suture of the skin is all that is necessary.

Ligation of Anterior Tibial Artery.—Fiotte and Delmas (Decouverte des Vaisseaux Profond. Masson & Cie, 1917), method is easier and gives freer access than does the classical operation and this is of considerable importance as in cases of hematomas resulting from wounds one does not know where the wound in the vessel is situated or even whether the artery has escaped while the vein has been injured.

In the middle third of the leg note the crest of the tibia and by palpation recognize the tibialis anticus muscle. Immediately external to the muscle there is a depression separating it from the extensor longus digitorum. Mark a point in this depression a little below the middle of the leg.

Make a mark in the depression in front of the head of the fibula. Join these two marks by an incision penetrating the skin (Fig. 1010). The incision will be about 5½ inches long and must be continued downwards until the separation between the tibialis anticus and extensor longus muscles is unmistakable.

Make a longitudinal incision through the fascia covering the intermuscular space. Separate the two muscles thus exposing the packet of vessels and the nerve. Using the finger pushed from below upwards in front of the vessels, as a guide it is easy to separate the muscles and divide the fascia until the most free exposure is obtained (Fig. 1011). When the wound is closed no disability results.

Ligation of the Posterior Tibial and the Peroneal Arteries at the Level of the Calf.—The classical method of exposing the posterior tibial artery is by an incision parallel to and a short distance behind the inner border of the tibia. After division of the deep fascia, the inner head of the gastrocnemius is pulled backwards to expose the soleus. The soleus is now divided fully half an inch from the tibia and the intermuscular septum is exposed stretching from tibia to fibula and covering the deep flexor muscles. In this intermuscular septum lies the artery with its venæ comites. A more or less similar operation with external incision serves for exposure of the peroneal artery.

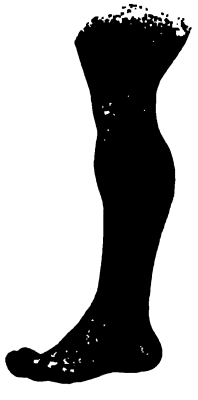


FIG. 1010.—(*Fiotte and Delmas.*)

FIG. 1011.—(*Fiotte and Delmas.*)

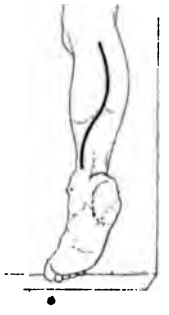


FIG. 1012.—(*Fiotte and Delmas.*)

When the soleus is penetrated recognition of the septum is difficult especially if the tissues are badly infiltrated with blood. For precise work a better exposure and especially simultaneous exposure of both the tibial and peroneal vessels and of the posterior tibial nerve are desirable.

Fiotte and Delmas Method.—Place the patient in the prone position with the dorsum of the foot resting on the table, thus relaxing the tendo Achilles.

Step 1.—From a point two finger breadths below the flexion fold of the knee make an incision downwards between the two heads of the gastrocnemii. Continue the cut downwards to the bottom of the belly of the muscle and then direct it medianwards to end midway between the tendo Achilles and the internal malleolus about 2 cm. (¾ inch) above the insertion of the tendon, Fig. 1012. Retract the external saphenous vein and nerve outwards. The nerve is a good guide to the interstice between the two heads of the gastrocnemius.

Step 2.—At the lower end of the incision divide the fascia along the inner side of the tendo Achilles and through this button hole introduce the finger as

if to hook up the tendon. Push the finger upwards in the loose conn tissue anterior to the tendon until it lies anterior to the soleus, *i.e.*, it is inev in the intermusclar septum containing the vessels (Fig. 1013).

Step. 3.—Keeping the finger in front of the soleus as a guide, separat two heads of the gastrocnemius and incise the soleus vertically in the m line until the guiding finger is reached (Fig. 1013). Enlarge the wound i soleus as much as necessary. Retract the edges of the wound in the muscl withdraw the guiding finger.

FIG. 1013.—(*Fiotte and Delmas.*)

FIG. 1014.—(*Fiotte and Delmas.*)

Under a thin layer of fascia it is easy to see the posterior tibial nerve wh is white and of good size, with the tibial vessels internal and close to The peroneal vessel lies about $\frac{1}{2}$ inch external to the nerve.

It is easy to expose about 3 to 4 inches of the vessels and nerve by the ab method (Fig. 1014).

Step 4.—Close the deep wound with buried sutures. Close the skin wou If drainage is required a tube may be laid in the tunnel formed by the fi in front of the tendo Achilles.

CHAPTER LXIV

OPERATIONS ON VEINS

Most of the operations on veins are so similar to those on arteries tha special description of them is necessary; a few, however, demand more partic consideration.

WOUNDS IN VEINS

When a small vein is wounded, the best treatment is, of course, to stop bleeding by the pressure of a compress or forceps or by the application ligature. When a larger vein is completely divided, the same treatme proper. Occasionally a vein is wounded in such a location that it is impos to apply a ligature; in this case the bleeding may be stanched by packing

ınd with gauze, or a forceps be applied and left in place for from twenty-
ır to forty-eight hours or longer. During operation in various localities,
tably the neck and axilla, a large vein may easily be wounded by accident
design. The wound may be picked up in the jaws of an artery forceps and
igature applied laterally, so that the wound is closed, while circulation con-
ıues in the vein whose calibre is of course considerably diminished.

Schede improved on the above treatment by closing the wound with sutures.
e used thin catgut introduced by fine Hagedorn or, better, rounded or intes-
ıal needles. The swelling of the catgut after it has been introduced closes
e needle punctures and prevents escape of blood through them.

The method of suture employed is the ordinary continuous stitch, including
its bite all the coats of the vein. Bleeding is prevented during suturing by
ıger or sponge pressure applied above and below the wound, or by forceps
tached close to the wound itself. In the hand of Schede, venous suture has
ever failed in giving satisfaction.

In removing a cancerous kidney Schede threw an elastic ligature around the
dicle and included a portion of the vena cava in the ligature. On examination
the pedicle it was found that the walls of all the vessels were diseased and
lividual ligation was impossible. It was impossible to leave the elastic
nstrictor *in situ*. "Under careful compression of the vena cava, above and
low, by means of spongesticks, the ligature was removed. Violent hemor-
ıge took place from the opposite renal vein. The wound in the vena cava was
ickly closed by two artery forceps so placed that their blades surrounded the
ınd by converging from above and below, their points meeting near the middle
the vena cava. Bleeding ceased and the remnants of the tumor could be
noved. A hole about ¾ inch in length was found in the vena cava. This
ıs sutured. The forceps were removed. There was no bleeding." The
tient lived for thirteen days. Postmortem, narrowing of the vena cava was
ınd at the site of operation, the wound was solidly healed, the intima was
ıooth, and there was not the slightest trace of thrombosis. Damar Harrison
ıs has a similar experience.

J. Petit (ref. Journ. de Chir., Aug., 1912) finds that 50 per cent. of the pub-
hed cases of wounds of the inferior vena cava occurred during operations for
nal cancer. Treatment by permanent tamponade need not be considered as
s results are deplorable. Forcipressure by leaving hemostats *in situ* gave
recoveries in 7 cases; lateral ligature 2 recoveries in 3 cases. This method
hould be reserved for cases of tearing of the renal vein when a short pedicle
ists convenient for ligation." In 14 cases of complete ligation of the vena
va there were 6 deaths. After ligation "the circulation in the lower limbs
rarely troubled, in but 3 cases was there œdema and that soon disappeared
two of them. Ligation then may be employed in wounds situated below the
nal vein." Lateral suture is the treatment of choice; in 19 cases of lateral
ture there were only 2 deaths. When the lesion is *above* the renal vein, lateral
ture should be attempted in every case. Below the renal vein lateral suture
ould be done except when the operation has been too prolonged; when the
ınd is infected or when the wound is irregular and transverse.

Eloesser (Jour. A. M. A., Jan. 30, 1915) in excising a cancer had to cut away

part of the femoral vein. The patient was 78 years of age, the veins were thick and sclerotic. Hemorrhage was temporarily stopped by pressure. "A bit of fatty tissue removed from the wound in the groin was tacked over the opening in the vein by a fine silk stitch which did not pierce the vein itself, but passed through the adjacent tissue and was crossed over the graft. On releasing the pressure there was no further bleeding." Death ensued in 12 days from senile delirium. The graft had united, was not necrotic and there was no clotting of blood in the vein.

INFUSIONS AND TRANSFUSIONS

Since the popularization of intravenous medication and especially since the wide spread use of Salvarsan or its equivalents, the operation of intravenous injection of salt solution and of blood whether 'whole' or citrated, has become almost a medical, rather than a surgical operation, physicians having more opportunity than surgeons to become skilled in the introduction of cannulæ into veins. When the veins are small and much collapsed exposure by incision is still necessary. During the Great War the treatment of shock and the result of hemorrhage was relegated in the A. E. F. to teams, each consisting of one *physician*, one nurse and one orderly.

Apart from the transfusion of blood in pernicious anemia, infusions and transfusions are mainly indicated for the treatment of shock and hemorrhage. They are valuable also as prophylactic measures before and after severe operations. They have their use in the treatment of stubborn sepsis. In some cases of hemorrhage without demonstrable cause, blood from another suitable individual may not only replace that lost, but may add the constituents necessary for the prevention of further bleeding.

In severe wounds it is practically impossible to separate the manifestations of shock and hemorrhage. A patient suffering from hemorrhage may require restoration of (*a*) the volume of the circulating medium, (*b*) the oxygen carrying agent, (*c*) both the volume and the oxygen carrying agents.

To restore volume, normal salt solution is excellent but unfortunately it often soon leaves the vessels and passes into the serous cavities, the intestines or is excreted in the urine. To overcome this fault gum acacia has often been added to the salt solution but clinical experience has shown this to be far from without danger and the results have not met the claims made for it originally by Bayliss, Cannon and others. With all its drawbacks infusion of salt solution remains the best means for increasing volume of circulating medium. Water by mouth, rectum or under the skin (preferably by mouth) must be used to keep up the volume as intravenous infusion is only a means to temporarily aid the patient.

Transfusion of blood is supreme in providing oxygen carrying agents but it also must be aided by the routine administration of water, and when volume is too scanty by infusion of salt solution.

Methods for Estimating the Volume of the Blood and Its Hemoglobin Content.—Determine the hemoglobin of blood drawn preferably from a vein in the arm. Infuse 500 c.c. of salt solution into a vein. Promptly determine the hemoglobin of the now diluted blood. If the patient's hemoglobin was 80 per cent. be-

fore the infusion of 500 c.c. of salt solution and if after the infusion it was 10 per cent. less, then 10 : 80 :: 500 : x or the blood volume, *i.e.*, 4000 c.c. after the infusion or 3500 c.c. before the infusion. Assuming that the normal blood volume is between 5000 and 6000 c.c. according to the size of the individual the loss in volume is easily apparent and one can estimate the absolute hemoglobin in terms of percentage (Roger I. Lee).

These data determine whether the patient requires increase in blood volume, increase in the oxygen carrying constituent or increase in both. Roger I. Lee writes (Am. Jour. Med. Sc., Oct., 1919) "theoretically, at least, the percentage of total hemoglobin when subtracted from 100 gives the percentage of blood loss. For example, a man presents a blood-volume of 4500 c.c. against his estimated normal of 6000 c.c., or 75 per cent. His relative hemoglobin is 80 per cent. His actual total hemoglobin is 60 per cent. Presumably he has lost 40 per cent. of his blood or 2400 c.c. However, he has replaced by fluid either from his tissues or his fluid intake or both 900 c.c., as his blood-volume deficiency is only 1500 c.c. We assume that it is the 900 c.c. of fluid addition to his depleted blood-volume which has diluted his hemoglobin from 100 to 80per cent. Of course, this argument presupposed that the man originally had both a normal blood-volume and normal hemoglobin. In general the evidence indicates that these presuppositions are reasonably sound.

In some instances these losses represented well over half the total amount of blood. In those cases we early came to recognize a very important fact. If the blood-volume was not being restored at least to an appreciable extent the prognosis was very grave, irrespective of treatment. In other words, when natural forces tended to restore in its normal fashion the blood-volume the prognosis was relatively good. We came to recognize the fact that, contrary to the usual off-hand snap judgment, but strictly in accord with logical reasoning, if a patient presented himself at the end of twenty-four hours or more with a relatively low hemoglobin, say of 60 to 80 per cent., that patient was in much better condition than one who presented himself with a hemoglobin of over 100 per cent., or the well known phenomenon of blood concentration in shock. In the most severe cases we found an astonishingly low blood-volume, sometimes under 30 per cent. of normal and an absolute hemoglobin of under 20 per cent. It may be repeated parenthetically here that in such cases the relative hemoglobin might be normal. Such cases in our experience, unless due to very recent large hemorrhage, and unless immediately corrected by large transfusions, were fatal. It became clear that, as had been observed clinically, there was a considerable group of cases of hemorrhage and shock in which, on account of the severity of the condition, little could be expected of any remedial measures. Another not inconsiderable group was made up of those cases who had no tremendous blood-loss but who had a blood-volume ranging around 60 per cent. In those cases the execution of the obvious indication of partially restoring the blood-volume by infusion was followed by elevation of the blood-pressure and of the apparent restoration of the patient to a condition of relative well being.

Perhaps the most interesting group of patients was the intermediate group between the two above groups. In this group the indication was for both the

restoration of blood-volume and of the oxygen-carrying constituent. In some of these cases simple transfusion was enough. Other cases required both transfusion and infusion. In some cases within a relatively short time over 1000 c.c. of blood and in addition over 1000 c.c. of fluid were administered."

Infusion of Salt Solution.—In an autoclave sterilize a 0.9 per cent. solution of common salt in distilled water for one hour at 15 lb. pressure.

A rough and ready means of preparing the solution is to add a heaping teaspoonful of salt to one pint of water and to boil the solution. The water must be free from floating particles. As some bacteria such as *bacillus capsulatus aerogenes*, are very resistant to boiling, it is safer to use the autoclave.

All the apparatus required for infusion is a glass funnel, a few feet of rubber tubing and an aspirating needle. A salvarsan outfit is excellent. All these are easily sterilized by boiling.

Apply a bandage around the arm of the patient sufficiently tightly to cause the veins at the front of the elbow to become prominent. Sterilize the skin with tincture of iodine. Fill the funnel with salt solution at a temperature of about 105°F. Introduce the cannula very obliquely into the chosen vein with the point of the cannula directed towards the heart. Let a little of the solution flow out of the tube to make sure there is no air in it.

As soon as blood flows from the cannula connect the rubber tube to it and permit the solution to flow. Slowly remove the bandage compressing the arm. Elevate the funnel and keep it well filled with the warm salt solution. Watch the patient's respiration and heart action. Any sign of pulmonary œdema or cardiac embarrassment calls for immediate stoppage of the infusion.

If the vein is so collapsed that insertion of the cannula is difficult or impossible, expose it by incision and introduce the cannula into it directly.

TRANSFUSION OF BLOOD

The Donor.—In the A. E. F. convalescent patients acted as donors. The donor ought to be in good physical condition and be free from any communicable disease. Unless time is too precious the Wassermann test should be made. The blood of the donor must be compatible as regards hemolysis with that of the recipient. Every individual may be classified in one of four groups according to the agglutinative reaction of their serum and corpuscles with the sera and corpuscles of individuals of the three other groups. Hemolysis never occurs when agglutination is absent.

The following table shows the relation of the four groups with respect to agglutination.

		Serum			
		I	II	III	IV
cells	I	o	+	+	+
	II	o	o	+	+
	III	o	+	o	+
	IV	o	o	o	o

+ = agglutination
− = no agglutination

In group I it will be noticed that the serum agglutinates no corpuscles but that its corpuscles are agglutinated by the sera of each of the other groups. Thus members of group I

may be transfused from any other group, they are "universal *recipients* while members of group IV are universal donors."

If recipient is in Group I donor may be selected from groups I, II, III, IV.

If recipient is in Group II donor may be selected from groups II IV.

If recipient is in Group III donor may be selected from groups III IV.

If recipient is in Group IV donor must be selected from group IV.

"Method of determining Blood Groups.

In order to determine the group of an individual, it is sufficient to test his corpuscles against known sera of Groups II and III. This is readily accomplished by a microscopic test described by Vincent, which, in addition to the two known sera, requires only a glass slide, a needle, and two small glass rods. (Citrated sera for this test are furnished by the Division of Laboratories.)

The test is prepared as follows:

Place a drop of Group II serum on the left half of a glass slide (slide need not be sterile, but should be clean and dry), and a drop of Group III serum on the right half of the slide. Puncture the ear or finger of the individual to be tested, and transfer in turn to each of the sera, about ⅓ of a drop of blood, on the end of the glass rod, mixing the blood intimately with the serum. In making the test, care should be taken to transfer the blood before coagulation has commenced, and also to avoid mixing the two sera. A separate glass rod should be used for each transfer. Agitation of the slide accelerates the appearance of an agglutination.

The red cells make a uniform suspension in the citrated serum. If there is no agglutination and the test is negative, this suspension persists. If the test is positive and agglutination takes place, it usually appears in less than a minute in the form of masses of agglutinated cells, easily discernible to the naked eye. In the rare instances in which the reaction is questionable the donor should not be used.

Rarely there is a tendency to rouleaux formation, which may be confusing. Rouleaux formation appears more slowly than agglutination, and, contrary to agglutination, is dissipated if the rouleaux are broken up by stirring the serum. [illegible] for the recently inducted in the U. S. Army. [illegible]

The formal grouping of donors is convenient and important when it is desired or necessary to keep a record of each, but the whole test can be made less formally as described by Fred H. Clark.

"First sterilize the arm of the patient with alcohol, then with ether, and with a sterile centrifuge tube containing a small amount of [illegible] of blood, then mix it by inverting the tube [illegible] trifuge the mixture [illegible] wash the sediment with normal saline, then centrifuge the tube a second time and pipette off the saline and then make [illegible] sediment is to be used, suspend by adding normal saline.

Centrifuge the tube of [illegible] and pipette off serum [illegible] donor [illegible]

Test [illegible] and add [illegible]

2. In the same way [illegible] donor's serum.

3. To the [illegible]

4. To the [illegible]

Finally add to each [illegible] for two hours.

Tests [illegible] ing taken to make [illegible] nor's and recipient's [illegible] glutination is [illegible] nors safe for use.

TRANSFUSION OF 'WHOLE' BLOOD

Simple Syringe Transfusion (Lindeman, Am. J. Dis. of Children, July, 1913).—Lindeman thus describes the operation:

"The entire apparatus for simple syringe transfusion consists of two sets of cannulas, two tourniquets and twelve syringes.

"*Cannulas.*—Two sets of cannulas are employed, one for the donor, the other for the recipient (Figs. 1015 and 1016).

"There are three cannulas to each set (Fig. 1016; 1, 2, 3,). Each cannula telescopes within the other as shown in Fig. 1015.

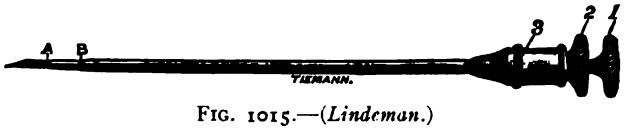


FIG. 1015.—(*Lindeman.*)

"The innermost cannula is practically a hollow needle, $2\frac{6}{16}$ inches long, 20-gage, with one end ground to a fine point and short bevel.

"The hollow needle (1, Fig. 1016) is fitted snugly into cannula 2. Cannula 2 is 5 mm. shorter than the needle and is fitted snugly into cannula 3. Cannula 3 is 5 mm. shorter than cannula 2. The proximal ends of 1 and 2 are capped with stationary thumb-screw caps.

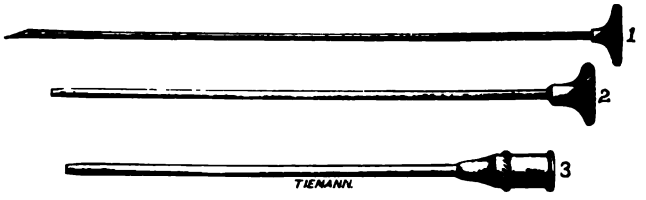


FIG. 1016.—(*Lindeman.*)

"The proximal end of 3 is capped with a receiver to fit any Record syringe.

"Cannula 3 is 2 inches long, 14-gage, .064 diameter. The calibre of this cannula is the same as the tip of a Record syringe.

"In very small infants with very small veins only cannulas 1 and 2 are employed, 2 being capped with the receiver to fit tip of syringe.

"The syringes used are Record syringes of new improved type with a capacity of 20 c.c. and can be sterilized by boiling.

"*Operation.*—One operator manages syringe of recipient. Another operator manages syringe of donor. An assistant stands between operators, who are in a position close to the assistant. Donor and recipient are placed in the recumbent position. Suitable veins are selected.

"In adults and most children over 2 years of age the median basilic is easily accessible. In infants the external jugular or one of its tributaries is entered more advantageously. In some cases the internal saphenous may prove the vein of preference.

"A tourniquet is placed in position, and the skin is sterilized with iodin. e cannula is then held in a position almost parallel to the vein with the thumb the thumb-screw cap of the innermost cannula (1, Fig. 1015). The skin is n punctured and the cannula is forced into the vein. After the first joint as entered vein, cannula 1 is withdrawn a distance of about one-half inch is prevents the vessel wall from being injured or punctured by the needle er the vein is entered).

"With the thumb now on the thumb-screw cap of 2 the cannula is forced ther in until the second joint B (Fig. 1015) has entered the vein. Cannula 2 hen withdrawn a distance of about one-half inch (cannula 3 alone can come o contact with the vessel wall). Cannula 3 is then gently pushed into the in to a desirable length; usually three-quarters to one inch will suffice.

"Cannulas 1 and 2 are now withdrawn entirely. If the vein has been suc- sfully entered, blood will flow through the cannula. When the first drop pears, a syringe containing warm saline solution is immediately attached d a very slow flow of saline is maintained through cannula. Escape of blood thus prevented.

"There is no need of haste at this stage.

"A cannula is next inserted in vein of donor in a like manner; again a syringe ntaining warm saline is attached and loss of blood thus prevented. Every- ing is now in readiness for the transfusion.

"An empty syringe is substituted for the one containing saline solution, d blood is withdrawn from donor as rapidly as possible.

"When the syringe is full the assistant passes it to the operator on the recipi- , who removes its saline syringe, attaches the syringe containing blood and cuates the contents gently but speedily into the vein.

"One syringeful of blood is followed by another in rapid succession until the ired quantity of blood has been transfused.

"A little normal saline is injected through cannula of recipient after each ingeful of blood. This keeps the cannula free of blood and precludes the sibility of clotting.

"It has been found advisable for the assistant (or third man) to remove the inge from the cannula of the donor as soon as filled.

"The operator can thus hold the cannula in place with one hand while h the other hand he may at once adjust an empty syringe into the cannula. ss of blood is thus reduced to a minimum.

"*Rules.*—1. Bright polished surfaces of syringe and cannulas are uisite.

"2. A syringe used once should not again be employed until thoroughly ansed with sterile water.

"3. Air must be avoided. This, however, offers no difficulty.

"4. Tourniquet of patient must be removed after vein is entered with nnula.

"5. Tourniquet remains on donor throughout operation; momentary release tourniquet may be advisable once or twice during course of operation.

"6. Dexterity and speed are requisite for success.

"7. Syringes can be evacuated more rapidly than they can be filled with-

out any harmful effects. This difference in time allows attachment of syringe with warm saline following each syringeful of blood.

"*Comments.*—The time elapsing in filling and evacuating the syringe is so brief that blood does not undergo any alteration from donor to recipient.

"No lubricant has been employed except in one case. Cannulas are lined with a film coating of albolene.

"Both arms of the donor may be used simultaneously.

"Larger syringes with larger calibred cannulas may be used, but the present sizes have worked satisfactorily and fittings of syringe and cannulas are of universal gage.

"Syringes and cannulas may be kept sterile in individual metal containers. They are thus in readiness for immediate use and no preparation for operation is required.

"The same vein can be used repeatedly for subsequent transfusions, since no thrombosis nor permanent injury to vessel occurs.

"Any quantity of blood can be transfused and the quantity definitely measured at the time of transfusion."

Lindeman (Jour. A. M. A., June 7, 1919) has succeeded in making 214 consecutive transfusions of 1000 c.c. or more of blood without a chill. This result was due not merely to the method employed but to the careful choice of donors. The post-transfusion rise of temperature is somewhat higher when more than 1400 c.c. is used. The rise of temperature usually begins from two to four hours after the operation and begins to decline in from four to eight hours. Occasionally a transient urticaria is observed. Lindeman believes that reactions after transfusion are due to four causes: "(1) hemolysis and agglutination; (2) toxic substances developed in the blood on remaining outside of the body; (3) chemicals such as anticoagulants and physiologic sodium chloride solution, and (4) sensitization and anaphylaxis."

Citrate of Soda or Lewisohn's Method (Jour. A. M. A., March 17, 1917, page 862).—This method was universally adopted by the Allies in the Great War.

Principles Involved.—1. Citrate of soda in two-tenths of 1 per cent. (0.2 per cent.) concentration prevents the coagulation of blood outside the body for from two to three days.

2. Five grams of citrate of soda can be safely introduced into an adult. Larger amounts are very toxic.

3. Citrated blood causes a temporary shortening of the coagulation time of the recipient's blood, but this is usually adjusted in less than twenty-four hours.

The Operation.—(1) *Obtaining the Blood from Donor.*—Apply a tourniquet to the donor's arm sufficiently tightly to make the superficial veins prominent. Choose one of the prominent veins in the elbow region (usually the median cephalic) and sterilize the skin over it with Tr. iodine or with alcohol. Puncture the vein with a cannula of fairly large caliber. Watson facilitates the insertion of the needle by transfixing the skin and the superficial segment of the vein with an ordinary seamstress needle, Fig. 1017. Collect the blood in a graduated glass jar which contains some two per cent. (2 per cent.) sodium citrate solution. If it is expected to use 450 c.c. of blood there should be

c.c. of the 2 per cent. citrate in the jar thus giving a 0.2 per cent. solution en the blood is added. Lewisohn advises the use of a few cubic centimeters he citrate solution lest the resultant blood mixture should contain less than minimum percentage of citrate.

(2) *Infusion of the Blood into Recipient.*—As the recipient is usually exceedly anemic the vein must be exposed by incision in about 80 per cent. of the es. Insert the cannula into the vein. Attach to the cannula a salvarsan

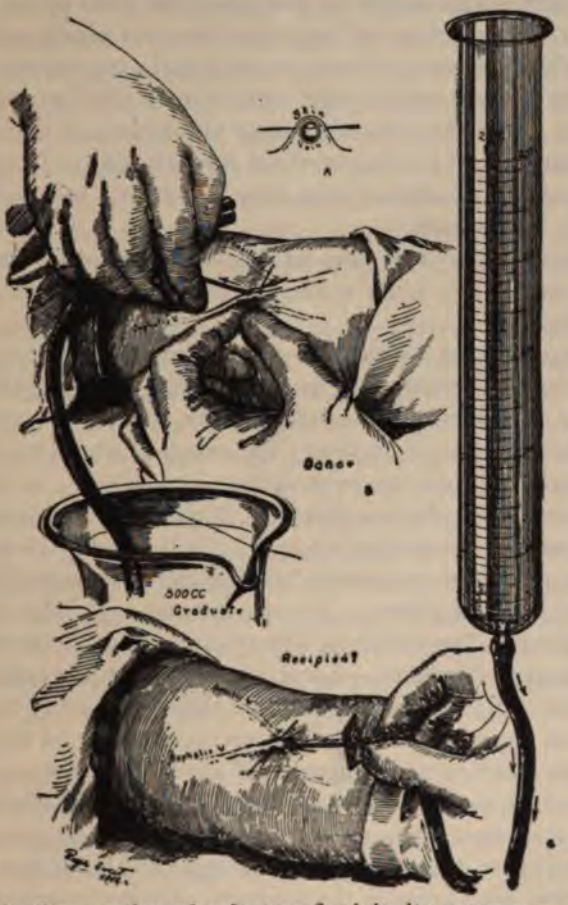


FIG. 1017.—A, Cross-section of vein transfixed in its upper segment to skin by a ight intestinal needle. B, Introducing Kaliski cannula into the cephalic vein of the or. The vein is steadied and prevented from rolling from under the cannula by means light traction exerted upon the transfixing needle. C, Cannula introduced in vein of pient. (*Pemberton in* "Surgery, Gynecology and Obstetrics.")

paratus which contains 20 or 30 c.c. of normal salt solution. Pour the citrated od into this apparatus and let it flow into the vein exactly like an ordinary ne infusion. Rarely more than 1000 c.c. of blood requires to be used and s only contains two grams of sodium citrate, a perfectly safe dose.

Infective Phlebitis.—For many years it has been customary to ligate the rnal jugular vein to prevent dissemination of infection in cases of sigmoid us thrombosis. The same treatment is applicable in acute thrombophlebitis

in other localities. The principle of the operation is to ligate the vein at a point proximal to the thrombus and then to open and clean out the vein where it is diseased, or still better to excise the diseased segment. Trendelenburg records a case of general chronic puerperal infection which recovered after double ligation of the inflamed and thrombosed right hypogastric (internal iliac) and spermatic veins. The details of the operation required are practically the same as for similar procedures on the arteries.

Varicose Veins.—The excuse for the superficial veins of the leg becoming varicose is that being outside the deep fascia they are poorly supported.

The principle of treatment of varicose veins is the transference of the venous circulation from the superficial to the deep veins, but before attempting to do this it must be shown that there is neither thrombosis of the deep veins nor marked obstruction to the return of blood through them. It must be remembered that varicosed superficial veins may be nature's means of dodging obstruction of the deep vessels.

Mayo, in doubtful cases, applies an elastic support to the limb for a week; if this gives comfort it is fairly evident that the deep vessels are capable of doing their duty.

Trendelenburg, struck by the fact that regurgitation of blood takes place from the deep femoral into the long saphenous vein, doubly ligated and divided the latter close to the saphenous opening. The operation is a good one when the condition is due to regurgitation. The test for regurgitation is as follows: (1) Elevate the limb until the veins empty themselves. (2) Make pressure over the vein near the saphenous opening. If the superficial veins now quickly become prominent Trendelenburg's operation will probably be inefficient. (3) The veins have not become prominent; still keeping up pressure at the saphenous opening, let the limb hang down. Remove the pressure. If a column of blood passes *down* the vein, Trendelenburg's method will probably be efficient.

Trendelenburg's Operation.—Local anesthesia usually suffices. Place a rubber band around the upper part of the thigh sufficiently tightly to cause dilatation of the superficial veins. This precaution may be dispensed with if desired. At the junction of the upper and middle thirds of the thigh make a longitudinal incision about one and one-half inches in length along the course of the vein. A transverse incision is preferable in fat patients. Expose and isolate the vein; ligate it with catgut at the upper and lower ends of the wound; excise the portion lying between the ligatures. Close the wound with sutures. Dress. Repeat the above procedure at a point immediately below and one immediately above the internal condyle. Keep the limb at rest for from two to three weeks. When painful varicose tumors are present, the author always supplements the Trendelenburg operation by excising such.

Delbet's Operation.—As Trendelenburg noted, varicosity of the long saphenous vein is due to inefficient valve action at its junction with the femoral, thus the whole weight of the blood in the inferior vena cava comes to bear on the saphenous vein. Below the junction of the two veins valves exist in the femoral vein. Hesse and Schaak found these valves constant in a hundred subjects and that while they were usually present 3 to 4 cm. (1⅛–1½ in.) below the junction yet occasionally they were 7 to 10 cm. (2¾–4 in.) below. If the

saphenous vein is doubly ligated and divided high up as in Trendelenburg's operation and its lower segment is anastomosed to the femoral vein below the site of the valves then there can be no serious reflux of blood and yet circulation through the saphenous vein is not impeded or prevented as is the case after most of the classical operations. The operation consists in isolating and ligating the long saphenous vein at its upper end and in making an end-to-side anastomosis between the lower segment of the saphenous and the femoral veins, *i.e.*, uniting the open end of the saphenous vein to the sides of a suitable incision made in the femoral vein. As in 73 per cent. of patients the femoral valves are situated close to the normal sapheno-femoral junction Delbet establishes the anastomosis 4–5 cm. (1½–2 in.) below that point while Hesse and Schaak prefer to make it 10 cm. (4 inches) below the junction, *i.e.*, about 20 to 25 cm. (8–9¾ in.) below Poupart's ligament. Delbet has had excellent results in 25 cases while out of 23 cases Hesse and Schaak lost one from severe streptococcic infection. To the author venous anastomosis seems entirely too serious an operation for varicose veins and that much simpler measures give very satisfactory results.

Cecca's Operation.—In certain uncomplicated cases of varicose veins where the long saphenous presents no old secondary lesions and where its branches are not extensively dilated, R. Cecca (Ref. "Journal de Chir.," i, No. 9) suggests giving support to the diseased vessel by transplanting it under the fascia. The operation consists of exposure of the vein by a long incision—incision of the fascia—insertion of the vein through the long wound in the fascia—suture of the fascia over the vein—closure of the skin wound.

Katzenstein performs an operation very similar to Cecca's. Through a long incision isolate the long saphenous vein and its affluents; isolate the sartorius; place the vein under the muscle applying a few sutures to the borders of the muscle. "The saphenous vein is thus imprisoned in a contractile muscular tunnel and while the varices in the leg do not completely disappear yet the pain disappears, the leg loses its feeling of weight and the patients state that they are relieved."

Phelp's Operation.—Multiple subcutaneous ligation. Pass a handled needle with its eye near the point, through the skin, behind the vein, and out through the skin on the opposite side of the vein. Thread the needle with stout silk; withdraw the needle and unthread it. Through the same puncture reintroduce the needle; pass it in *front* of the vein and out through the skin puncture on the opposite side of the vein made in the previous movement. Thread the free end of the silk ligature in the needle and withdraw the needle. By the above means a silk ligature has been made to surround the vein, and its ends emerge through the same puncture in the skin. Tie the ligature tightly. Repeat the operation at about thirty or forty places. Apply dressings and prescribe rest in bed.

Mayo's Operation.—C. H. Mayo excises the long saphenous vein as follows: Expose and isolate the vein near the saphenous opening. Divide the vein between ligatures. Seize the peripheral portion of the vein with a hemostat.

Pass the end of the vein through the loop of Mayo's dissector (Fig. 1018, *a*). Guided by the vein push the dissector under the skin down to a point near the knee, cut through the skin over the end of the dissector; clamp the vein, pull it out through the wound, ligate and excise the loose portion. If the dissector is obstructed in its work by adhesions around the vein, pass the closed forceps (Fig. 1018, *b*) alongside it, and when the adhesions are reached open the blades

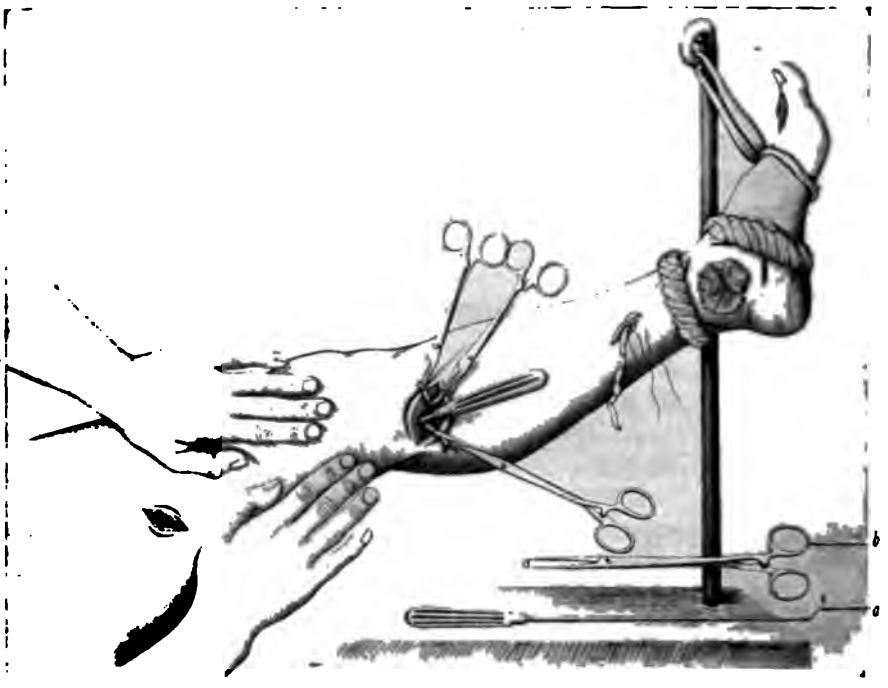


FIG. 1018.—Excision of varicose veins. (*Mayo.*)

of the forceps slightly; this usually overcomes the trouble and the dissector can complete the work. In the same manner remove, subcutaneously, as many other veins as may be necessary. The dissection should be from above downwards to avoid the danger of detaching thrombi and throwing them into the circulation.

Removal by Inversion.—W. L. Keller's operation ("N. Y. Med. Journ.," Aug. 19, 1905). Elevate the limb. Expose the long saphenous vein near the saphenous opening. Divide the vein between clamps. Ligate the proximal stump. Split the upper end of the distal segment for about three-quarters of an inch on its anterior wall. Tie a strong ligature to the upper end of the vein (Mamourian uses a suture), care being taken not to include more tissue in the ligature than will pass through the lumen of the vessel. Apply traction to the distal stump and thus make the vein prominent along its course as far as the

knee. Expose the vein by a small incision on the inner aspect of the knee. Divide the vein between two clamps. Ligate the distal segment. Remove the clamp on the proximal segment and pass a long probe, eye first, up the lumen of the vein until it comes out of the first incision. Thread the ligature on the probe. Pull on the distal end of the probe and so extract the vein at the same time turning it outside in.

Marmourian writes ("Brit. Med. Journ.," July 16, 1901): "All the prominent veins of the leg can be dealt with in similar fashion. If they are very tortuous, a gum-elastic catheter should be used instead of the probe. The method is not applicable to cases of general or cirsoid varicosities."

Babcock's Operation.—("Journ. A. M. A.," July 16, 1910.)—Babcock has improved an operation which he published in 1907. A special instrument required is a long, pliable probe with a small acorn tip at one end capable of passing through the lumen of the vein to be removed; at the other end is a larger acorn tip, the shaft surface of the acorn being so cuffed as to catch the wall of the vein and prevent its inversion and slipping over the end of the instrument.

Expose the vein either at the upper or lower end of the segment to be removed (preferably the upper end, to obviate dangers of embolism (J. F. B.)). Grasp the vein with a hemostat. Incise the vein and introduce the smaller end of the probe. Pass the probe along the inside of the vein for the required distance or until some obstruction is encountered. With strong silk tie the vein to the shaft of the probe close to its larger acorn end. Divide the vein between the hemostat and the probe. Replace the hemostat by a ligature. Incise the soft parts including the wall of the vein over the smaller end of the probe which may be felt or seen. Grasp the small end of the probe and pull it out of the wound by firm traction combined with a series of short jerks. The vein comes away pleated firmly in a small fusiform mass against the concavity of the larger bulb of the instrument. The procedure may be repeated on other varicose veins as required.

Excision of Varicose Veins.—*Excision of the whole Internal Saphenous System.*—Make an incision, slightly curved with convexity posterior, from the upper end of the saphenous opening to the posterior border of the internal condyle of the femur. Expose the vein where it dips through the saphenous opening, doubly tie and divide it as high as possible, above the point of entrance of the superficial external pudendal vein (Alglave). If there are varicosities of the superficial abdominal veins Alglave recommends that they also be ligated through an extension of the incision upwards. (The author would be chary of doing this lest the varicosities should happen to be the result of some intra-abdominal venous obstruction.) Reflect the edges of the skin wound widely so as to expose, from above down, the saphenous trunk and its branches. The whole inner side and some of the anterior surface of the thigh is exposed. If there is found a collateral trunk of the vein this must be followed, if necessary, through a secondary incision. Large varicose branches must also be included in the excision. Grasp the upper end of the vein and, making slight traction on it, dissect downwards. The traction makes all branches prominent so

that they are easily clamped and divided. When the lower end of the wou reached do *not* cut away the mobilized packet of veins. Attend to hemos Suture and protect the major portion of the wound. Continue the in down the leg to a point in front of the internal malleolus. Below the reflect the skin forwards to near the tibial crest and backwards to abou middle of the calf. Putting slight tension on the veins already removed the thigh, continue the dissection downwards to beside the ankle. Along the veins remove the surrounding fat and connective tissue, *i.e.*, excise e thing between the deep fascia and the skin. Save as many branches o internal saphenous nerve as possible. Close the wound.

FIG. 1019.—Friedel's operation. (*Friedel.*)

If the skin is healthy the above operation is easy but if there are n adhesions and if the skin is thin and much altered it becomes impossibl improper.

If the skin lesion is not extensive it may be best to excise that area of along with the veins; if it is extensive and if the dissection is difficult one be content with excising the main trunks, if necessary removing large var branches through separate incisions. It is not always necessary to ma continuous incision from Scarpa's triangle to the ankle. If one desires may make suitable incisions in the thigh and leg and burrow under the between them opposite the knee. Naturally if the internal saphenou affected only in the leg, the operation on the thigh may be omitted.

Excision of External Saphenous System.—Make an incision through the

from the middle of the popliteal space to a little above the external malleolus. Remove the vein and its branches in the manner already described.

When limited areas of veins are alone varicose, these, of course, may be excised through any suitable incision.

Schede's Operation.—In the upper third of the leg make an incision completely round the limb, dividing all the tissues down to the deep fascia. As the cut is being made doubly ligate and divide all the veins.

Von Wenzel's operation is the same as Schede's *plus* a similar circular incision at the junction of the middle and lower thirds of the thigh.

Friedel's Operation ("Archiv für klin. Chir.," lxxxvi, p. 143).—When the veins in the leg are not only increased in size but in numbers and repeated attacks of inflammation have so imbedded them in scar tissue that excision is impossible, Friedel's operation gives promise of value. Much œdema is usually present, giving the limb an appearance of elephantiasis—ulcers are almost always evident and the question of amputation arises.

FIG. 1020.—Friedel's operation. (*Friedel.*)

The Operation.—*Step* 1.—Doubly ligate and divide the long saphenous high up in the thigh.

Step 2.—With a knife mark a spiral line running round and round the leg from a point below the disease to a point well above it. The closer together the rings of the spiral lie, the oftener will the veins be divided and the greater the probability of cure. When ulcers are present the spiral should surround the leg *both* above and below them. Necrosis of the skin has not developed as a result of the spirals being close together.

Step 3.—Guided by the marks on the skin, make an incision down to the deep fascia. As this cut is made inch by inch, widely retract the edges of the wound and ligate or throw a stitch around each vein which does not stop bleeding under simple tamponade. Continue the cut until it follows the entire length of the spiral traced on the skin in Step 2 (Fig. 1019).

Where an ulcer exists join the spirals above and below it by two vertical incisions so as to cut off the veins coming from the ulcer (Fig. 1020).

Step 4.—Pack the whole length of the wound so that it must heal by granulation. During the after-treatment destroy all superficial granulations which might fill up the wound before epidermization takes place. It is of importance to have the epithelium spread from the skin down into the depth of the wound so that a very deep permanent spiral gutter is formed giving the leg somewhat the appearance of rolled beef.

The author has used Friedel's operation or some modification of it, with satisfaction.

RESULT OF OPERATIONS FOR VARICOSE VEINS

Jeannel (French Congress of Surgery, 1910, remarks that some surgeons class as cured cases in which there may be persistence of varicosities if they are less voluminous or less painful and disabling than before operation; other sur-

geons only class as cured patients in whom the varices no longer exist and who have restored to them a healthy, vigorous, painless limb. In the following tables taken from Jeannel the latter conception of the word "cured" is adopted.

A. Results of operations directed against the superficial reflux of blood.

(*a*) Trendelenburg's operation and its variants.

Six hundred and ninety-seven limbs operated on and examined after the lapse of from two months to twelve years.

393 cured	56 per cent.	
90 doubtful	13 per cent.	
214 failures	31 per cent.	44 per cent.

(*b*) Resection of whole femoral part of the internal saphenous vein.

Twenty-three limbs operated on and examined after from two months to seven years.

*12 cured	52 per cent.	
3 doubtful	22 per cent.	
6 failures	26 per cent.	48 per cent.

B. Results of operations directed against the deep reflux of blood.

(*a*) Excision of isolated varices.

Seventy limbs operated on.

*52 cured	74 per cent.	
3 doubtful	4 per cent.	
15 failures	22 per cent.	26 per cent.

(*b*) Resection of all or most of the internal saphenous or of the external saphenous vein.

Fifty-seven limbs operated on and examined after from two months to eight years.

*26 cured	46 per cent.	
12 doubtful	19 per cent.	
20 failures	35 per cent.	54 per cent.

C. Results of operations directed against both superficial and deep reflux of blood.

(*a*) Trendelenburg's operation with its variants plus multiple ligations and resections both in the thigh and leg.

Ninety-five limbs operated on and examined after from one month to fourteen years.

57 cured	60 per cent.	
21 doubtful	22 per cent.	
17 failures	18 per cent.	40 per cent.

* These figures are copied from the abstract of Jeannel's article in the J. de Chir., Vol. V, 1910, p. 637. The author is not responsible for the apparently peculiar arithmetic.

(*b*) Complete saphenectomy.

Seventy-seven limbs operated on and examined after periods of from a few months to seven years.

73 cured	95 per cent.
4 failures	5 per cent.

These tables of Jeannel's show the importance of recognizing in any individual case whether the trouble is purely due to superficial reflux of blood when Trendelenburg's operation or one of its variants ought to suffice; or whether the trouble is due to a deep reflux of blood or to both superficial and deep reflux when one of the more radical operations will be necessary.

LYMPHANGIOPLASTY (HANDLEY'S OPERATION)

In about 16 per cent. of cases of breast cancer diffusion of the disease and perilymphangitis causes obstruction of the lymphatics about the shoulder which leads to œdema of the arm. This œdema causes intense suffering and disability for which opiates or amputation were the only relief until Handley devised his simple operation.

The operation of lymphangioplasty has *no* effect on the carcinoma; it merely provides new means for the lymphatic drainage of the arm. Handley's results have been most gratifying in relieving suffering, deformity and disability.

Materials required: Several long probes provided with an eye at one end; a supply of No. 12 tubular woven silk.

The Operation.—*Step* 1.—Make a one-inch incision through the skin in the midline of the front of the forearm immediately above the wrist (Fig. 1021, *a*).

Step 2.—Introduce a probe under the skin through incision *a*. Pass the probe upwards and outwards to the point *b* near the elbow. At this point incise the skin and push the point of the probe out through the incision.

Step 3.—Take a double line of silk more than twice as long as the arm and catch its mid-point with a hemostat. Protect one half of the silk by wrapping it in a towel and thread the other half through the eye of the probe. Pull the probe and with it the silk out through incision *b*. The hemostat attached to the silk prevents too much being pulled out. A double line of silk now lies in the subcutaneous tunnel *a*–*b* made by the probe.

Step 4.—Reintroduce the probe through the incision *b* and bring it and the silk out through incision *c* made near the insertion of the deltoid.

Step 5.—Pass a second probe through incision *a*, upwards and inwards and make it emerge through incision *d*. The half of the silk line which was wrapped in a towel is now unwrapped and threaded through the eye of the probe. Pull the probe and with it the silk out through incision *d*. Remove the hemostat from the middle of the silk so that the loop of silk becomes buried under the skin at *a*.

Step 6.—In the same fashion pass the silk under the skin from *d* to *c*.

Step 7.—Reintroduce both probes through incision *c* and pass them under

the skin round the shoulder to emerge through incision *f* made at the poster border of the deltoid (Fig. 1022).

Step 8.—In the same manner bury a double line of silk under the skin of t back of the arm along the lines *g h f* and *g k f*. There are now eight threa emerging through incision *f*.

Step 9.—Take a long probe, cut off the ends of two of the emerging threa so that they are four inches shorter than the probe and thread them into t eye. Thrust the probe, eye first, through incision *f* and make it penetrate und the skin of the back. The probe being longer than the silk, unthreads itse Withdraw the probe carefully leaving the two silk threads to occupy its trac

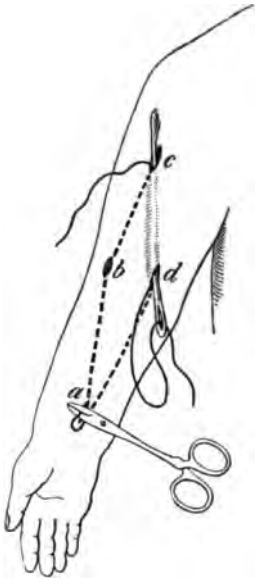


FIG. 1021.

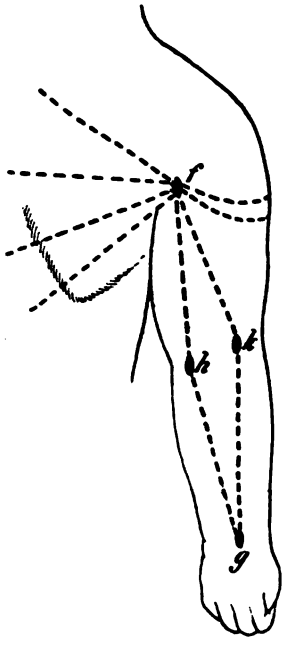


FIG. 1022.

FIGS. 1021 AND 1022.—Lymphangioplasty.

Repeat this manœuvre until all the threads which emerge at *f* have been tucked in various directions into subcutaneous tissues of the back.

Step 10.—Close all the incisions with sutures.

Handley writes ("Brit. Med. Journ.," April 9, 1910.

The choice of cases for lymphangioplasty.

"The analysis of my cases shows that lymphangioplasty is contraindicate in cases where a general anesthetic cannot be borne, and in cases where sil threads would have to pass through cancerous tissue. It is also inadvisable t operate where there is growth present about the shoulder, if the pain is mainl an axillary one, or is a lancinating pain shooting down the arm. In the presenc of pleural effusion or secondary growths the benefits of the operation are tran

ient, but the shortest period of relief may, under the circumstances, be considered by the patient as worth having.

"Minor degrees of obstruction to the return of lymph from the arm are not infrequently met with in breast cancer. The operation of lymphangioplasty should not be applied indiscriminately, but should be reserved for the severer degrees of lymph-stasis in which other modes of treatment are powerless.

"The axillary scarring which necessarily follows removal of glands may sometimes lead to persistent œdema of the arm, usually slight in amount. In such cases the application of a bandage and the elevation of the arm on an inclined plane for one or two hours a day will usually suffice. In other cases, which ultimately develop into the true brawny arm, the lymph obstruction is partial only. In such cases, although the arm may attain a very considerable size, the œdema is soft and pits freely on pressure. Postural treatment by elevation will sometimes in this stage reduce the size of the arm considerably, and will, to some extent, relieve the pain. The necessity of operation is thus for a time deferred, but the relief obtained is not to be compared with that resulting from lymphangioplasty. It appears, moreover, to be very transient, and in many cases even before the œdema has become solid, postural treatment is intolerable because it severely aggravates the pain. This fact is easily explicable, since the lymph from the forearm, flowing easily upwards into the arm and meeting obstruction there, distends the tissues of the upper arm to an unbearable extent."

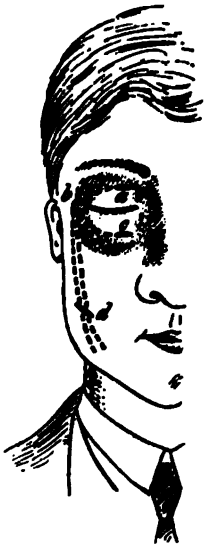


FIG. 1023.—Lymphangioplasty.

Elephantiasis.—Handley has applied lymphangioplasty to the treatment of various œdemas of the lower extremity —elephantiasis, Milroy's disease (congenital œdema), etc.—but finds that while temporary benefit was obtained the condition always promptly recurred.

W. Clark ("St. Bartholomew's Hosp. Reports," xlv, 1909, Ref. Zeut. f. Chir., 1910, No. 18) reports a case of œdema of the leg of uncertain origin but of nine years' duration. Implantation of a thread on the inner side from the dorsum of the foot to above the knee gave distinct improvement.

A. B. Mitchell ("B. M. J.," No. 20, 1909) reports a case of solid œdema of the eyelids on both sides which followed a severe attack of erysipelas and resisted all ordinary treatment. Handley's operation was performed as follows:

1. Make the very small curved incision *a* (Fig. 1023) on the upper eyelid. Through incision *a* pass a probe under the skin to the point *b* at the outer margin of the orbit; expose the point of the probe by incising the skin at *b*. Thread a strand of coarse silk on to the eye of the probe and pull it through the subcutaneous tunnel made by the probe between *a* and *b*.

2. Similarly incise the lower lid at *c* and pass a strand of silk under the skin to emerge at incision *b*.

3. Pass a probe through incision *b* and push it downwards under the skin to the point *d* where a small incision permits the probe to emerge. Thread the two

strands of silk emerging at *b* through the eye of the probe and pull them through the subcutaneous tunnel *b d*.

4. With a probe or director introduced through incision *d* make a small pouch under the skin below *d* and into this tuck the ends of the threads.

5. Close all skin wounds.

In Mitchell's case one of the threads caused irritation and had to be removed; the other remained *in situ;* the result was good.

In the case of a young soldier who suffered from solid œdema of the left side of the face and lips due to erysipelas following excision of enlarged cervical glands Mitchell implanted two silk threads the upper ends of which were fastened to the fascia covering the masseter, the lower ends being tucked into the loose tissue behind the clavicle.

"The result was entirely satisfactory; the threads never gave the slightest trouble; the face resumed the natural contour."

Kondoleon ("Zent. für Chir.," No. 30, 1912) finds that in most cases of old elephantiasis from any cause "besides the well-known alterations in the skin and subcutaneous tissues, the fascia is always much thickened (up to 3 cm.), densely infiltrated, immobile, and adherent especially to the fat lying between it and the skin. The outer surface of the fascia is irregular, of a milky hue; the inner surface next the muscles is of normal color and consistence." In a few cases one can separate the fascia from a sheet of connective tissue which lies between it and the subcutaneous fat, in other cases this separation is impossible. Most of the retained lymph lies in the neighborhood of the above-mentioned sheet of connective tissue. Kondoleon finds that if the lymph can gain access to the muscles it is promptly absorbed and he has had apparent good results (though his cases were not observed sufficiently long to permit of definite conclusions) from the following operation:

1. The disease is confined to the leg. On the outer side of the leg make a longitudinal incision through the skin from near the knee to near the ankle. Reflect the skin on each side of the incision until a strip of fat about 4 finger-breadths wide is exposed. Excise this fat. Excise the thickened deep fascia to an equal extent. Attend to hemostasis. Close the skin wound without drainage. Do the same on the inner side of the leg.

2. The thigh and leg are both involved. After operating on the leg as above described, perform an identical operation on the thigh.

Royster ("Journ. A. M. A.," May 30, 1914), Matas. Sistrunk (Trans. Surg. Section, A. M. A., 1918) have had good results from the Kondoleon operation.

A similar operation may be used for elephantiasis of the arm.

CHAPTER LXV

OPERATIVE TREATMENT OF SIMPLE FRACTURES, EXCLUSIVE OF THOSE INVOLVING ARTICULATIONS AND OF SOME SPECIAL FRACTURES

Until recently all closed (simple) fractures were treated without operation; to-day most of them are and ought to be exempt from operation. All open (compound) fractures demand operation.

In February, 1911, a committee was appointed by the Council of the British Medical Association "to report on the ultimate results obtained in the treatment of simple fractures with and without operation."

The committee limited its inquiry to simple fractures of the long bones which occurred or in which operations were performed in the period January, 1906, to December, 1910. Every patient reported upon was examined by a member of the committee. The following are the conclusions formulated by the committee:

I. The statistics relative to the non-operative treatment of fractures of the shafts of the long bones in children (under the age of 15 years), with the exception of fractures of both bones of the forearm, show as a rule a high percentage of good results. These are unlikely to be improved upon materially by any other method of treatment. Operative results in children, expressed in percentages, are approximately the same as the non-operative. The relative figures are: Non-operative cases (cases 1017) 90.5 per cent. good functional results. Operative cases (cases 64) 93.6 per cent. good functional results.

II. It is possible either by non-operative or by operative treatment to obtain a high percentage of good results in children.

III. In comparison with the non-operative results in children, the aggregate results of non-operative treatment in those past childhood (*i.e.*, over the age of 15 years) are not satisfactory.

IV. From the analysis of the age groups it is clear that there is a progressive depreciation of the functional result of non-operative treatment as age advances, that is to say, the older the patient the worse the result.

V. In cases treated by immediate operation, the deleterious influence of age upon the functional result is less marked.

VI. In nearly all age groups, operative cases show a higher percentage of good results than non-operative cases.

VII. Although the functional result may be good with an indifferent anatomical result, the most certain way to obtain a good functional result is to secure a good anatomical result.

VIII. No method, whether non-operative or operative, which does not definitely promise a good anatomical result, should be accepted as the method of choice. For this reason mobilization and massage by themselves have not been found to secure a high percentage of good results. They are, however,

valuable supplementary methods of treatment. Similarly, of operative methods, those which secure reposition and absolute fixation of the fragments yield better results than methods which fall short of this; imperfect fixation of the fragments by wire or other suture has been found to be an unsatisfactory procedure in the treatment of the fractures of the long bones, with the exception of the olecranon process of the ulna.

IX. Operative treatment should not be regarded as a method to be employed in consequence of the failure of non-operative measures, as the results of secondary operations compare very unfavorably with those of immediate operations. In order to secure the most satisfactory results from operative treatment, it should be resorted to as soon after the accident as practicable.

X. It is necessary to insist that the operative treatment of fractures requires special skill and experience, and such facilities and surroundings as will ensure asepsis. It is, therefore, not a method to be undertaken except by those who have constant practice and experience in such surgical procedures.

XI. A considerable proportion of the failures of operative treatment are due to infection of the wound, a possibility which may occur even with the best technique.

XII. The mortality directly due to the operative treatment of simple fractures of the long bones has been found to be so small that it cannot be urged as a sufficient reason against operative treatment.

XIII. For surgeons and practitioners who are unable to avail themselves of the operative method, the non-operative procedures are likely to remain for some time yet the more safe and serviceable.

(A) **Immediate Operation.**—Immediately after receipt of injury the tissues are freshly lacerated; there is no effusion from irritation; the lymphatics are not clogged with dead material being removed. Unfortunately, from the trauma, much tissue is so injured that its resisting power is lowered and hence an amount of accidental infection, which would be harmless in a wound made during an ordinary operation, might lead to serious consequences. Immediately after injury the conditions are therefore partly favorable and partly unfavorable for operation. Arbuthnot Lane favors early operation.

(B) **Delayed Operation.**—Within a few hours of the receipt of injury the extravasated blood clots in the tissues; coagulable lymph is effused throughout the injured area; the normal lymphatic drains of the part are either overworked or clogged; the bruised but still living tissues have not recovered tone; the whole injured area is in the least favorable condition to withstand any accidental infection. This unfavorable condition persists for about seven days.

(C) **Late Operation.**—During the second week after injury the injured tissues have recovered tone; much of the extravasated blood, etc., has been absorbed; the lymphatic drainage system is in good working order; the ends of the broken bones have gone through the process preparatory to repair. All conditions are favorable for operation. During the period of delay the usual means of reducing and treating the fracture have been faithfully tried and their failure demonstrates the necessity of operation. Some time during the second

week is the period of choice for operation—at a later date, nature's efforts at repair and the occurrence of contractures, etc., would seriously interfere with operative reduction.

PRINCIPLES OF OPERATION

I. **Preparation of Patient.**—If necessary expend several days in cleaning the skin of the part. Scrub repeatedly with soft soap and hot water, using the nail-brush or, better, some form of scrub-cloth. On the evening before operation wash with benzene, gasoline or alcohol. On the morning of the operation repeat this washing. On the operating table paint with iodine.

FIG. 1024.—Lane's forceps or tongs.

II. Make an appropriate incision where it will do least harm and give the most free possible access. Make the incision too long rather than too short. As soon as the skin is completely divided exclude it from the rest of the wound by sterile cloths held in place by a few stitches or by volsellæ. Complete the exposure of the fracture by blunt and sharp dissection.

Never touch the wound with the bare hand; make all necessary manipulations with instruments (König's rule). Do not let such parts of instruments as have

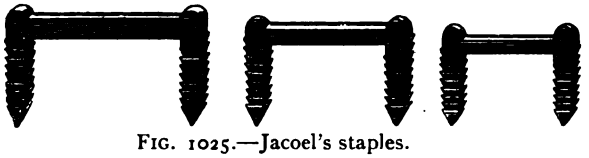


FIG. 1025.—Jacoel's staples.

FIG. 1026.—Int. splint.

touched the skin of the patient or the bare hand of the surgeon enter the wound. Lane in fact, does not permit even the *gloved* hand to enter the wound.

III. Having thoroughly exposed the ends of the bone, remove all blood-clot and materials intervening between them. Fritz König advises against a too thorough removal of *all* material between the fractured surfaces, as nature will attend to this and much of the material here present is of value in the formation of callus; it is only necessary to remove such structures as will probably interfere with union. König writes ("Archiv für klin. Chir.," lxxvi, 725): "except in resections (when union has been despaired of) or when there is abnormal effusion into involved joints, we do not concern ourselves much with blood-clots."

Lane, however, thinks that bones ought to unite with practically no call

Now attend to hemostasis and bring the fragments into apposition by mea of traction combined with the leverage action of powerful long-handled forcep Lane's forceps are shown in Fig. 1024. They are so constructed as to grasp t bones firmly and yet not exert injurious pressure. Different sizes of force are required for large bones, as the femur, and small bones, like the uln The forceps hold the fragments in place admirably while screw nails, staple

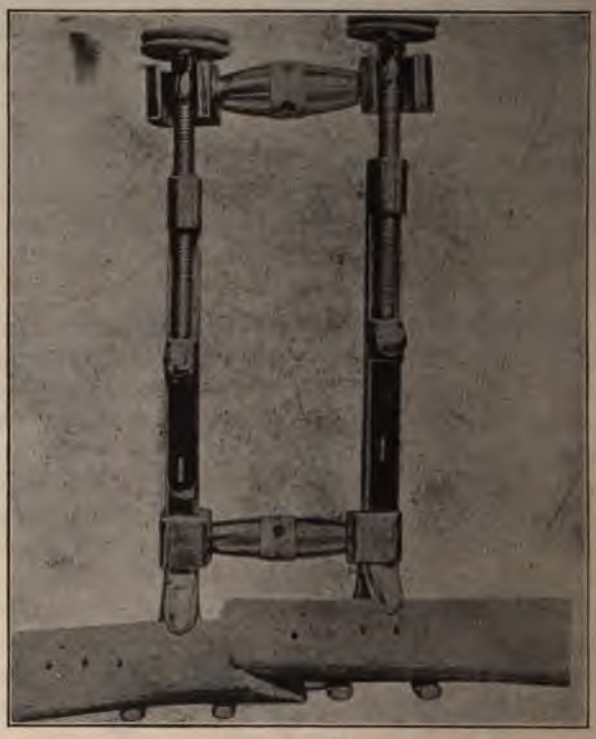


FIG. 1027.—(*Gerster, Annals of Surgery.*)

or metal splints are being applied. Lowman's bone and plate holder (Fig. 1039 is also a useful aid. John Gerster's turnbuckles (Fig. 1027) applied to Lowman' clamps are of service in obtaining and maintaining reduction. If the fragment tend to remain in apposition, close the wound with or without drainage an treat as a simple fracture. If there is any doubt as to the maintenance of app sition it is necessary to insure it by means of sutures (wire or chromic gut), peg screw nails (Lane), ordinary wire nails, intramedullary bone plates or tubes staples (Jacoël) (Fig. 1025), buried steel splints (Fig. 1026), Freeman's apparatu

* Carleton Flint used pegs made from fresh ox bone. These pegs, at first square in sectio are roughly rounded with a file and sterilized by boiling.

FIG. 1028.—(*Lane.*)

FIG. 1029.—(*Lane.*)

FIG. 1030.—(*Lane.*)

FIG. 1031.—(*Lane.*)

FIG. 1032.—(*Lane.*)

FIG. 1033.—(*Lane.*)

FIG. 1034.—(*Lane.*)

FIG. 1034 A.—(*Lane.*)

FIG. 1035.—(*Lane.*)

FIG. 1035 A.—(*Lane.*)

FIG. 1034 A.—(*Lane.*)

CHAPTER LXVI

COMPOUND OR OPEN FRACTURES

Practically every fracture communicating with the open air through a wound, no matter how trivial the wound may appear, ought to be subjected to operation. The object of the operation is the treatment of the deep wound; treatment of the fracture is a secondary consideration and may be carried out either at this time or later, as may seem best. The method of treatment varies according to the severity of the injury, the amount of dirt ingrained into the wound, and the conditions surrounding the patient. An elaborate method of operating with fixation of the fractured bones is very proper when a good operating-room and good assistance are available and yet may be quite improper under less favorable circumstances.

FIG. 1040.—Extension arm splint applied. (*Robert Jones, British Med. Journ.*)

FIG. 1041.—Modified Thomas' humerus extension splint applied. (*Robert Jones, British Med. Journ.*)

Example.—Compound fracture middle of humerus; small wound through skin; much laceration muscles. Unfavorable surroundings. Treatment adopted: Free enlargement skin wound; loose packing with gauze; immobilization in *comfortable* position, but no attempt at exact reposition of bones. Removal of pack in about 48 hours. Application of dressings and immobilization as before. Reduction of fracture on eighth day. Careful immobilization. If it had been easy to reduce the fracture and keep it reduced during the days when the wound required attention, immediate reduction would have been effected, but as it was the patient was comfortable, the wound healed well, and no time was lost. Thomas' splint or Jones' modification thereof (Figs. 1040 and 1041) give admirable immobilization and extension as well as permit easy access to the wound.

When it is evident that injury to the vessels, etc., of the part has destroyed all hope of maintaining the nutrition of the parts distal to the fracture, ampu-

tation must be done; under other circumstances conservative operation is imperative.

An operation for open fracture of the tibia may be taken as typical.

OPERATION FOR OPEN FRACTURE OF THE TIBIA

Step 1.—Anesthetize. Scrub the *whole* leg with soap and hot water, using a wash cloth. Shave the leg. Scrub the whole leg with turpentine, gasoline, or ether to remove grease. Scrub once more with soap and water. Scrub with alcohol. Scrub with some reliable antiseptic solution, preferably Harrington's solution (commercial alcohol (94 per cent.), 640 c.c.; hydrochloric acid, 60 c.c.; water 300 c.c.; corrosive sublimate, 0.8 gram). Instead of the above elaborate classical preparation one may use Grossich's plan, viz., avoid the use of water, shave off the hair (dry), paint with tincture of iodine. The English favor washing with alcohol then with 3 per cent. alcoholic solution of picric acid. Apply an elastic constrictor.

Step 2.—Enlarge the skin wound freely so that every nook and cranny of the deep wound becomes accessible. With gauze sponges, gloved finger, and instruments remove all foreign material, blood-clots, etc. Dissect away the ragged skin around the wound, also all portions of tissue so injured that they cannot live.* Remove completely all detached fragments of bone. These fragments Macewen scrubs thoroughly, lays aside in a warm aseptic solution and reimplants with good effect, when necessary. Too few surgeons follow Macewen's lead in this.

Fragments of bone still attached to the shaft by periosteum may be cleansed and retained. Remove all tissues which will interfere with union by becoming interposed between the fractured surfaces. With retractors open all torn tissue planes and spaces; clean such thoroughly with douche and mop. Provide free drainage for every part of the wound through counter-punctures when necessary. Reduce the fracture. If necessary for fixation, unite the fractured surfaces by sutures of wire or catgut or by means of the pegs, etc., described elsewhere. The objection to the use of wire, pegs, nails, etc., is the irritation which they are likely to keep up if the wound is or becomes infected. In an open fracture of the femur, where asepsis was evidently unattainable,

*In wounds from projectiles of high velocity very extensive excision of tissue (debridement) is necessary, much greater than in the accidents of civil life but the principles are the same viz., removal of all contaminated tissue and all tissue so injured as to become a pabulum for bacterial growth.

Martin and Petrie (Brit. Med. J., Oct. 6, 1917) made a very thorough study the spread of infection in the open bone. Applying the results of their investigation to the treatment of projectile fractures they come to the following conclusions.

1. Soft parts killed by the direct effect of the missile require removal.
2. An infected fracture of the shaft of a long bone requires opening to the full extent of the solution of continuity.
3. In infected fracture of cancellous bone the superficial debris of smashed trabeculæ, etc. requires removal. Solid bruised bone is able to resist infection and may be left.
4. As penetration of infection is at its maximum in the first few days early operation is essential, especially in fractures of cancellous bone involving joints.
5. Every artery directly or indirectly supplying a fractured bone is of importance in the defence against infection.
6. In the presence of vascular injury proximal to the fracture, radical measures, such as amputation or resection of a joint, may be adopted with less hesitation.

C. H. Mayo mortised the bones together (Fig. 1042) so that fixation was obtained without employing any foreign body. Remove the elastic constrictor. Attend to hemostasis by means of forceps, ligatures, and hot water. See that the drainage-tubes are in place and not clogged.

Step 3.—Partially close the external wound. Dress. Immobilize. The Thomas or the Hodgen splints are excellent.

Sinclair informed the author that the above was the basis of the very successful treament of fractures inaugurated by him in the British Service during the Great War. He is careful to operate with the splint (Thomas') *in situ* when dealing with thigh fractures.

J. Hogarth Pringle (Brit. Journ. Surg., II, No. 5) enunciates the following rules which he follows in the treatment of open fractures of the long bones.

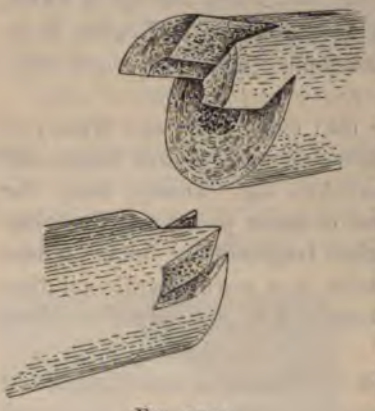


FIG. 1042.

Large fragments of bone ought always to be saved whether they have or have not been deprived of periosteum. They are preserved in warm salt solution until required, and if soiled, the infected surfaces are removed with a chisel. The preservation of such fragments is of special value if they represent the "third fragment" of a flexion or spiral fracture because if they are not implanted, two pointed and often narrow ends of bone are left, a pseudarthrosis may result, or, if union takes place, there is much shortening. Always use fixation by means of wire, screws, nails, plates, etc. Always excise the original skin wound. When confident of asepsis always try to close the wound even if relaxation incisions are required. These incisions should always be made if there is much undermining of the skin from violence.

Unless very confident of asepsis leave the wound open. This means delay, but without harm provided the exposed bone and fascia are kept moist. If the wound is open the fixing agents (plates, etc.) are left until consolidation is secure and are then removed.

Lilienthal (Trans. Am. Surg. Assoc., 1912) fixes the bone by means of Lane's plates, but instead of the ordinary screws he uses screws with the head prolonged into a steel shaft 3 to 5 inches long with a square pyramidal head to fit a key which is to be used instead of a screw-driver. To simplify extraction of the plate he threads a strand of silver-plated piano wire into the terminal apertures of the plate and lets this wire protrude from the wound with the elongated screw shanks.

This method being used in infected fractures, the wound is packed. The screws and plates are easily removed when no longer required.

In very complicated cases the author has often left the wound wide open, filling it loosely wtih gauze; if after a few days it is evident that asepsis has been attained the wound may be closed in whole or in part; if asepsis has not been attained the openness of the wound is a great element of safety. Always remember that treatment of the wound is of incomparably greater importance

an reduction of the fracture. If reduction of the fracture does not interfere ith drainage and wound treatment, then immediate reduction is indicated; reduction interferes in any way with efficient drainage, then partial reduction us as thorough as possible immobilization is the treatment of choice until the ains are removed when reduction should be carried out The Carrel-Dakin eatment of the wound gives good results and ought to permit of early closure. uring the after-treatment some form of interrupted splint is a great boon, as permits the dressings to be changed with the least possible disturbance of e parts. Thomas' splints for both upper and lower extremities and Hodgen's lint are of inestimable value.

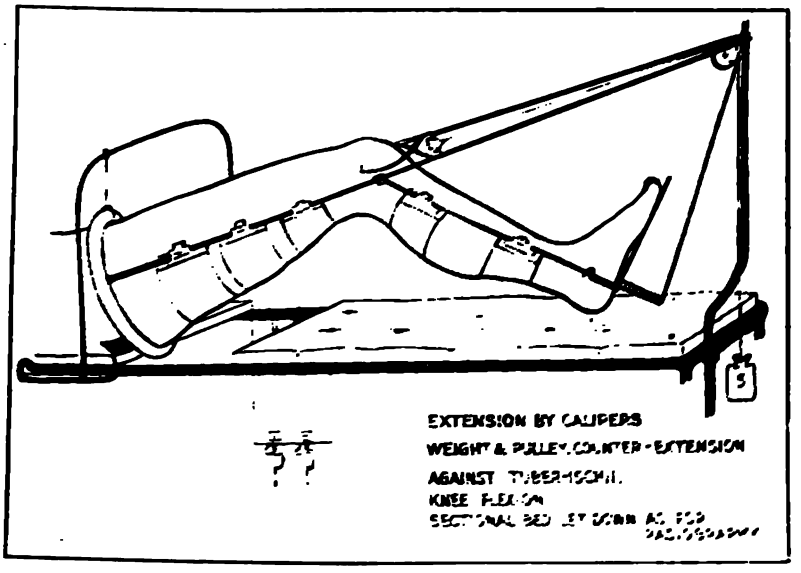


Fig. [illegible] — T. P. Jones [illegible]

To obtain the best results in the treatment of [illegible] e- and post-operative treatment is necessary. [illegible] e able to lower the mortality in fractures of the [illegible] l to obtain union without appreciable shortening [illegible] nsive loss of bone Sir Robert Jones [illegible] hony Bowlby, Brit. Med. Journ. [illegible] phs the principles which led to [illegible] y are as pertinent in civil as in military [illegible] taken as typical but similar [illegible] r bones.

1. On the battle field apply [illegible] or dressings applied [illegible] on the foot. Obtain [illegible] p or by a steel skewer [illegible] n of the patient with a [illegible] traumatizing the soft [illegible]

common ought to have a supply of Thomas Splints both for arm and leg and some of the employees ought to be trained in their application.

2. As soon as the hospital has been reached operate on the lines already indicated and put up in a Thomas' splint, the means of extension being now adhesive plaster or bandages fixed to the limb by a surgical glue. Direct extension by calipers is often best. Instead of the Thomas' splint various others may be employed but none should be chosen which do not permit easy access to the wound.

3. Regulate the amount of extension by means of a portable X-ray apparatus. The best results in the B. E. F. were obtained when the extension was such as to make the injured limb 'definitely longer than its fellow.' A gap of 1 or even 2 inches between the main fragments of bone can be completely filled with new bone. It is best to have extension with the knee slightly flexed.

4. Begin moving the knee early. The classical Thomas' splint is straight but if it is bent just above the knee and traction is maintained by Ransohoff's calipers or such like means any amount of knee flexion and extension can be secured without disturbing the fracture of the femur (Fig. 1043).

5. When union is sufficiently advanced use a walking caliper splint, which is merely a Thomas' knee splint in which the end is fixed into the heel of the shoe.

The following tables published by Bowlby are most striking.
Fractures of the Femur in two special British General Hospitals in France in 1918:
(*a*) 334 cases; average shortening 0.2 inches.
(*b*) 60 cases; average shortening 0.2 inches. (Of these 60 cases, 36 had no shortening.)
In a special Hospital in England, 1918:
68 cases. No shortening in 39. Average shortening in the remaining 29 cases = 0.5 inch.

An open fracture at the articular end of a bone may involve the joint in one or two ways: (*a*) A split or fissure may extend from the main site of fracture and the external wound into the joint. If such a fracture is seen early it is very improbable that infection will have reached the joint unless the fissure or split is short, *i.e.*, unless the distance from the point of articular involvement to the external wound is short. Under the above favorable conditions, treat the case as a compound fracture without articular involvement.

(*b*) There is free communication between the external wound and the joint. Treat the fracture *secundum artem;* treat the joint by arthrotomy, as if arthritis had already developed. The treatment of the consequences of articular infection will be considered elsewhere.

CHAPTER LXVII

UNUNITED FRACTURE. PSEUDARTHROSIS

The local causes of non-union of fractures are usually (*a*) separation of the fragments, (*b*) insufficient or improper immobilization, and (*c*) most important of all, interposition of muscle, fascia, or fat between the fragments. The principles of operative treatment consist in (*a*) removal of interposed tissue; (*b*) freshening of the ends of the bones; (*c*) obtaining and maintaining apposition of the fragments. If these principles are carried out with cleanliness, union is sure, provided that the local and general vitality, *i.e.*, the recuperative power, is sufficient.

Often long-continued non-union results in contracture or shortening of the soft parts and this, unless corrected, may prevent either the obtaining or maintaining of apposition of the fragments. Where moderate contracture is present Treves very wisely recommends that extension be applied to the limb for a week or more prior to operation. Edward Martin, in the case of an ununited fracture of the femur with 2½ inches of shortening, having failed to attain results by the usual means of traction, devised the following method: "It consists in a long, strong canvas strip pocketed in the middle and looped at the ends. The bones at the seat of fracture are freed, the pocket is slipped over the proximal end of the distal fragment, the ends of the canvas strip are carried in the long axis of the limb and in the loops is fixed a cord to which are attached the weights. By thumb pressure the bone is kept from angling out of the wound, and weights up to 100 pounds, or more, are attached to the rope. In from three to five minutes the shortening is overcome. Only those structures which interfere with proper placement are stretched, and this is done so thoroughly that there is but slight tendency to the reproduction of deformity" ("Surg., Gyn., Obst.," Jan., 1910).

Ochsner prefers gradual extension; he says " the only thing that is peculiar about the method is the application of rubber adhesive strips to as high a point above the seat of fracture as is possible."

"For instance, instead of applying the rubber adhesive up to the fracture, it should be applied over the entire length of the thigh, then, with no more than 24 pounds of weight, we have, in every fracture where there has not been a union, been able to stretch the muscles sufficiently to replace the fractures without making a resection of the ends. In cases where there is a union in malposition, the muscles will stretch to a marked extent. Extension may be supplemented in some cases by preliminary division of the contracted tissues, although such division is more commonly done at the time of the major operation." The *aim* of the surgeon must be to so operate that whatever means of fixation and immobilization (pegs, wire, splints, etc.) is used, its function may be as nearly as possible prophylactic, *i.e.*, the fragments of bone ought to be so prepared that they *tend* to remain in apposition.

METHODS OF OPERATING

Step 1.—**Exposure of the Bone.**—Select that route to the site of fracture which is shortest and which will necessitate least damage to the tissues. Remember the situation of important structures (*e.g.*, the musculo-spiral nerve in the arm) so as to avoid injuring them. If possible penetrate to the bone between muscles rather than through a muscle. Usually a longitudinal incision is best. J. E. Thompson's article on 'Anatomical Methods of Approach in Operations on the Long Bones of the Extremities' ("Annals of Surg.," lviii, 309, 1918) is well worth study.

The use of an elastic constrictor is optional, though it is preferable to avoid its use whenever possible. At the point selected make a vertical cut through

FIG. 1044.

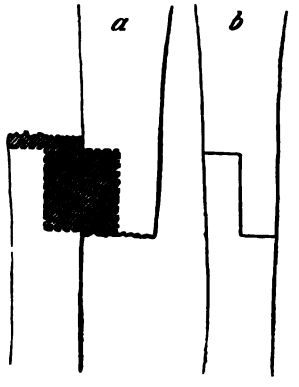


FIG. 1045.

the skin down to but not through the deep fascia. To find an intermuscular septum it may be necessary to reflect the skin from the fascia for a short distance on one or both sides of the incision. Divide the fascia over an intermuscular septum and by combined sharp and blunt dissection penetrate the septum to the bone. With retractors expose the bone. The length of the wound must be sufficient to give *free access* to the site of fracture. A small incision inevitably leads to much bruising and damage to the tissues during the rest of the operation. With a periosteal elevator or rugine separate enough of the periosteum (if possible *en masse* with the attached muscles) to permit of a thorough appreciation of the conditions to be dealt with. [Amount of fibrous tissue between the fragments; extent of separation; amount of bone atrophy; obliquity of the ends of the bone, etc., etc.]

Instead of exposing the fascia by a vertical incision one may reflect the skin as a flap by means of I-, or U-, Π-shaped incision. After the fascia is exposed the rest of the operation is as described above.

Step 2.—**Preparation of the Ends of the Bone for Their Union.**—The preparation of the ends of the bone depends on the conditions found at the site of fracture. The bones may be united by fibrous tissue, their ends may be conical from atrophy, there may be a wide separation between them or one

ment may have overridden the other, causing much shortening. The of fracture may be transverse, oblique, or irregular. (*a*) Dissect all ign material (fibrous tissue, muscle, etc.) from between the bones. (*b*) ossible, make each fragment of bone in turn protrude from the wound

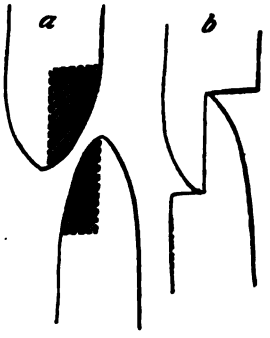


FIG. 1046.

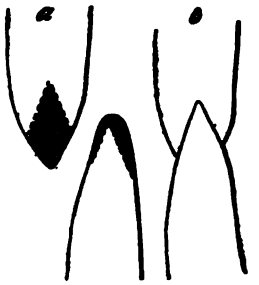


FIG. 1047.

vivify it by sawing off thin slices of the bone until a healthy bleeding surface tained. Sir Robert Jones (Surg. Gyn., & Obst., Jan., 1920) in case of mal- n rarely evacuates the ends of the bone through the wound but prefers to w the attached surfaces with a chisel and trust to extension without internal ting. (*c*) If it is impossible to make the ends of the bone protrude, vivify *in situ* by means of a finger or a Gigli wire saw or a chisel.

As a rule, an oblique fracture can be best vivified with a chisel; a transverse ure or one where the ends have become conical, with a saw. (*d*) When ying the ends of the bone it is often possible to so shape them that the one nent will mortise into the other and thus tend to remain in position. A

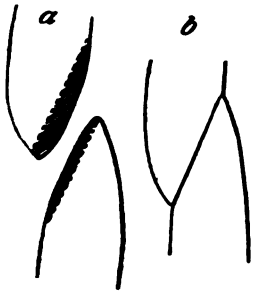


FIG. 1048.

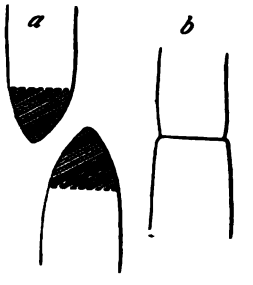


FIG. 1049.

or gouge is the best instrument with which to shape the ends of the bone. s 1044 to 1049 show various methods of vivifying and modeling the ends bones.

G. Wildey (Brit. J. Surg., II, No. 7, p. 423) operates on ununited fractures ws: Freely expose the site of fracture. Bring the ends of the bone out e wound. Vivify their terminal surfaces by removing a very thin slice

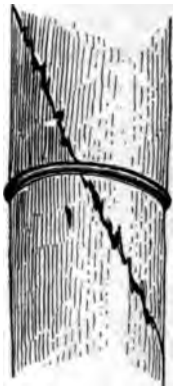


FIG. 1050.

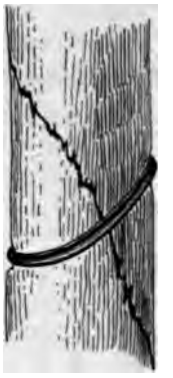


FIG. 1051.

FIG. 1050.—Improper application of wire.

FIG. 1051.—Proper application of wire. Note the wire is at right angles to the line of fracture.

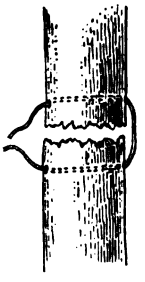


FIG. 1052.

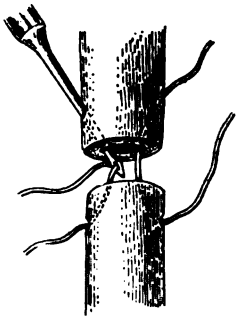


FIG. 1053.

FIG. 1054.

FIG. 1055.

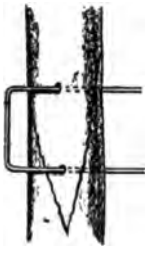


FIG. 1057.

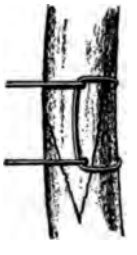


FIG. 1058.

FIG. 1059.

FIGS. 1057, 1058 AND 1059.—(*Monod and Vanaert.*)

ıch. Remove the plugs of callus or fibrous tissue from each end by a r drill. Drill the circle of indurated bone in four or five places *parallel ng axis of the bone*, using drills Nos. 1 to 3. The drills must penetrate ıal bone which is shown by lessened resistance to the advance of the drill bleeding. Usually a depth of from 1 to 2 inches is necessary to open a r area of bone. The deeper the perforation required, the larger should be l and the more numerous the holes bored. When both fragments have

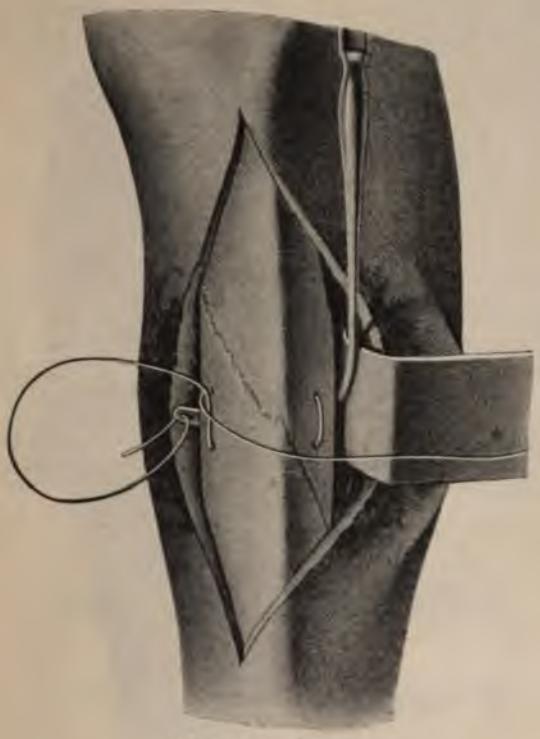


FIG. 1060.—(*Lejars.*)

eated, place them in apposition and secure fixation by means of Lane's Wildey finds that union is easily secured, is very firm, but that there is ccess of callus.

3.—**Union of the Bones.**—If the fragments show a marked tendency to in apposition, the wound may be closed and the case treated by splints, e any ordinary fracture. Unfortunately, the above is not commonly ıt and it becomes necessary to hold the bones together by some means directly to them. The methods devised for attaining direct union of ments are legion—a few of the principal ones will be given here.

hod A.—Suture of Wire or Catgut.—Figures 1050 to 1061, show how rse or oblique fractures may be fastened together with stout wire or hromicized catgut. If wire is used, the ends, after twisting, must be short and any sharp protruding ends must be hammered flat or directed

into the bone so as not to lacerate the soft parts. Most surgeons use silver or aluminum-bronze wire.

Method B.—Fixation by Nails or Bone Pegs.—Where the fractured surfaces are oblique, bore a hole transversely through both fragments—temporarily leave the drill *in situ*. With a second drill bore another hole through both fragments; remove this drill and replace it by a bone peg. Remove the drill first introduced and replace it also by a bone peg. The drill left *in situ* keeps the fragments in good position while the first peg is being introduced.

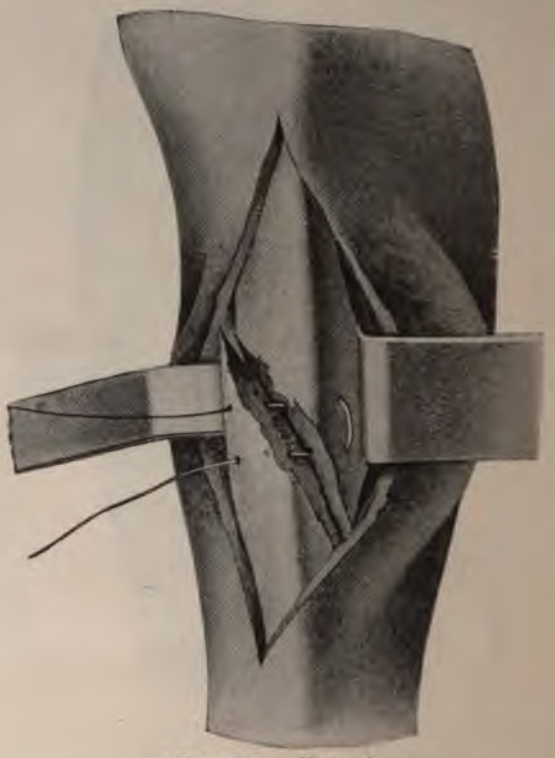


FIG. 1061.—(*Lejars.*)

Bone pegs are easily made from a bone knitting needle of convenient thickness and are sterilized by being boiled. When the pegs have been driven into position, any part which may protrude must be cut off flush with the bone. Instead of bone pegs metal nails or screws may be used in the same way.

Figures 1062 and 1063 show the application of pegs. Jacoël and Dujarier have devised useful metal staples to take the place of nails or screws (Fig. 1064).

Depage (Fig. 1065) provides a long screw which terminates in a pliable wire. After boring a suitable hole he passes the screw through both fragments. Guided by the pliable wire he threads a nut on to the screw and thus can get very firm approximation. The excess of screw is cut away. The objections to this procedure are the wide exposure necessary and the difficulty of removing the plate should that subsequently be necessary.

FIG. 1062.

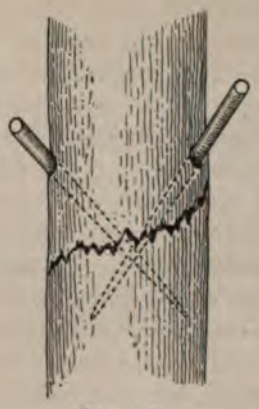


FIG. 1063.

FIG. 1064.—Jacoël's staples.

FIG. 1065.—Depage's screws.

FIG. 1066.—(*Cuthbert-Wallace, The Lancet.*)
owing the essential parts: 1. A bolt. 2. A nut with a soft wire brazed to one facet. 3. A flat spanner. 4. A clock-key spanner.

Cuthbert-Wallace (Lancet, May 15, 1915), to avoid extensive exposure of the bones in oblique fractures, uses a very simple bolt as follows: Expose the bone. Reduce the fracture. Drill a hole through the central point of the fracture. If the fracture is *not* very oblique the hole should be bored more or less at right angles to the line of fracture, otherwise it should be at right angles to the axis of the bone. The hole ought to be a little larger than the bolt. Push the bolt through the hole till its end just emerges on the opposite side. Holding the nut (Fig. 1066) by the wire attached to it, place it in position on the bolt and screw the bolt home with the clock-key spanner. Traction on the wire prevents the nut turning with the bolt. When fixation is accomplished cut off the end of the bolt protruding from the nut with strong pliers. Bend the wire around the bone to the head of the bolt. Cut off the excess of wire. The wire left *in situ* renders removal of the bolt easy if this is necessary at any time. If the bolt is introduced obliquely to the axis of the bone shaft its head can easily be housed by cutting a small hollow in the bone.

Method C.—Fixation by Drills or Long Metal Nails.—This method is the same as B, except that the drills used to perforate the bone are left *in situ* with their proximal ends protruding through the wound in the soft parts. After two or three weeks the drills become loose and are easily removed. Both methods B and C have given the author much satisfaction.

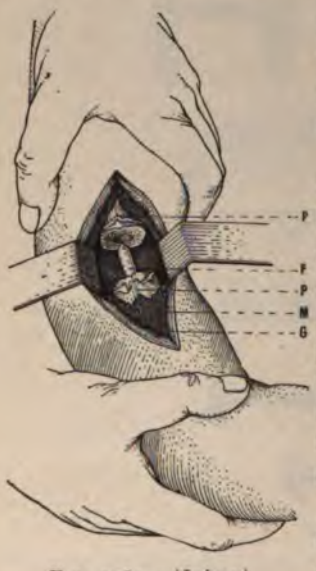


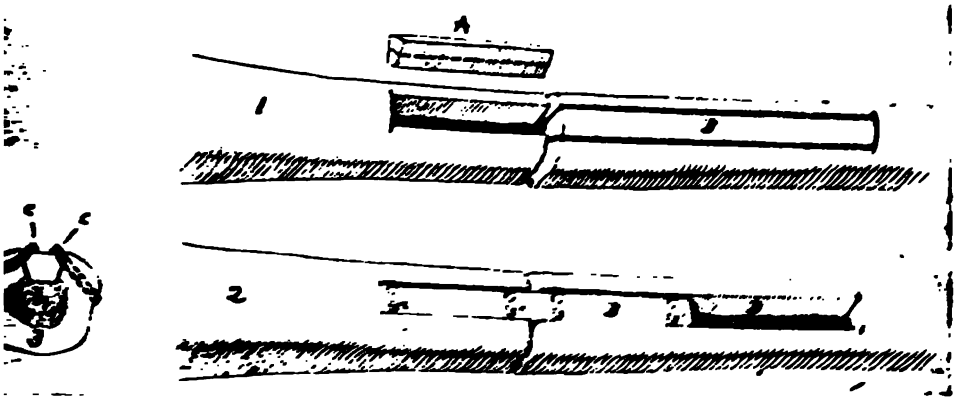
FIG. 1067.—(*Lejars.*)
P, Upper fragment; P′, lower fragment; F, Peg; M, Muscle; G, Fat.

Method D.—Fixation of Intra-medullary Pegs. Prepare beforehand several bone or ivory pegs of different sizes so as to be sure to have one about the calibre of the central cavity of the bone. Bend the limb so that the end of the lower fragment of bone is easily accessible; lightly drive a prepared peg into the medullary cavity for a distance of 1 to 1½ inches. Manipulate the limb so that the end of the peg protruding from the lower fragment enters the medullary canal of the upper fragment (Fig. 1067).

Murphy uses a transplant from the same patient as an intramedullary peg. The tibia is usually the source of supply. After vivifying the ends of the bone to be united, enlarge the marrow cavity of both the upper and lower fragments with a reamer or burr for a distance sufficient to form a good firm bed for the implant. Thorough reaming is an insurance against fat embolism. Pack the wound and protect it thoroughly. Make a longitudinal incision over and through the tibialis anticus and divide the underlying periosteum of the tibia near the crest. Retract the edges of the wound. Separate the periosteum from the crest of the bone. (The object in making the incision through the muscle is to have a good covering for the defect which will be left in the bone.)

Mark the upper and lower limits of the desired transplant by boring holes in the bone. With a saw make a transverse cut in the bone at each end of the

part to be transplanted. The transplant must usually be as thick as the surgeon's little finger or even fore-finger, and the transverse cuts must therefore be about ½ or ¾ inch deep. With a chisel cut a groove along the bone from the bottom of one transverse cut to the bottom of the other. This prevents splintering of the fragment. Apply a broad chisel or osteotome to the groove, cut through the bone and remove the fragment. Place the fragment in warm salt solution or moist gauze. Close the wound with deep and superficial sutures. Remove the pack from the wound exposing the bones to be united. Use the fragment of bone exactly as if it were an ivory or bone peg. It is of prime importance to have absolute contact maintained between the implant and its upper and lower bed, viz., the cavities prepared in the bones to be united. For this purpose it may be necessary to drill transversely through the receiving bone and the implant and insert a nail.



[illegible]

[illegible]

Even if apposition between the fragments of the [illegible] the implant will [illegible] with the [illegible] forty to sixty days.

Albee [illegible] enous graft or implant obtained from the [illegible] ciently described [illegible] site of fracture is usually [illegible] to obtain the graft from [illegible] himself.

Magnesic [illegible] fractures of [illegible] engths [illegible] is also made [illegible] part [illegible]

parallel incisions in the long axis of the bone and across the fracture. These cuts are the same length as the ivory plate and penetrate to the marrow cavity. Drill a hole at each end of the parallel cuts so as to mobilize the contained bone and permit its extraction. The result is a slot into which the ivory plate is now driven. At right angles to the plane of the plate drill a hole on each side of the fracture and drive into these holes ivory pegs or nails. Close the wound and treat as a simple fracture.

H. Platt (Lancet, Feb. 1, 1919) finds that there are two causes of failure after operations by bone graft for ununited gun shot fractures: (1) The waking up of latent infections, (2) the bad quality of the skin cicatrices which give way because of malnutrition.

Commonly a delay of six months is prescribed to avoid latent infection, but even after a year or more the latent infection may be present. It is better to excise all the scar tissue, vivify the ends of the bone and close the wound.

FIG. 1069.—(*Freeman.*)

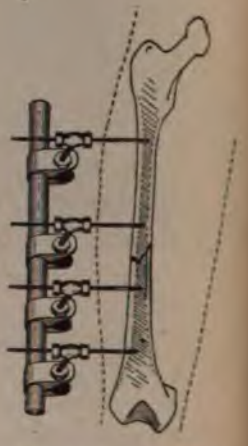


FIG. 1070.—(*Lambotte.*)

This can be done two months after healing of the original wound. The tissues are removed thoroughly *en masse* and are put in a sterile receiver for bacteriologic examination. In two or three weeks physio-therapeutic treatment can be begun. Six or eight weeks after this preliminary operation bone grafting can be safely attempted.

Method E.—Fixation by Means of "Fish Plates." Internal Splinting.—The best plates are those of Arbuthnot Lane made of stout steel. Such may be obtained in various sizes. W. O. Sherman finds plates of Vanadium spring steel stronger and less bulky than Lane's plates. The screws are of metal and should be a trifle over ½ inch in length. Figures 1029 and 1033 show clearly the application of "fish plates" to a bone.

Method F.—Fixation by Means of Long Screws and External Clamps.—This method has been recommended by Keetley, Parkhill and Freeman. The

application of Parkhill's most ingenious apparatus is difficult because of its complexity.

Freeman, by using strips of hard wood backed by steel plates (Fig. 1069) has rendered the method exceedingly simple. The attached figures sufficiently describe the procedure. Figures 1070 and 1071 show an exceedingly complicated apparatus on the same principles which has given Lambotte excellent results.

Lilienthal's Modification of the Parkhill-Freeman Device.—The apparatus may be used in closed or open fractures, the latter will alone be described here.

FIG. 1071.—(*Lambotte.*)

Provide four gimlets of the square-headed variety which fit in a brace or can be put in with a key; provide two rods of steel about the size of small telegraph wire. Near the fracture, bore one gimlet into the bone at right angles to the shaft, deeply enough so that there will be no play on gentle attempts at motion. Introduce a second gimlet an inch or two above the first. In the same manner introduce two gimlets into the other fragment. Reduce the fracture and hold the bones in place either by external manipulation or by bone clamps. The gimlets protruding from the wound are not in alignment. Apply the steel rods "in such a way along the line of gimlets and roughly parallel to the bone and

[illegible] the rods and guiders shall be in contact. If the guiders were in a perfectly straight line one rod would be sufficient, for it would reach all of them; but the line being a staggering one, two rods will be found necessary. The steel rods should be near the bases of the guiders, i.e., remote from the wound. Bandage the rods and guiders together with a plaster-of-Paris bandage sterilized by baking. Dismiss the wound again and loosely pack with gauze. Apply a light spiral dressing.

Hey-Groves' method "Lancet," Feb. 21, 1914, combines distraction with traction.

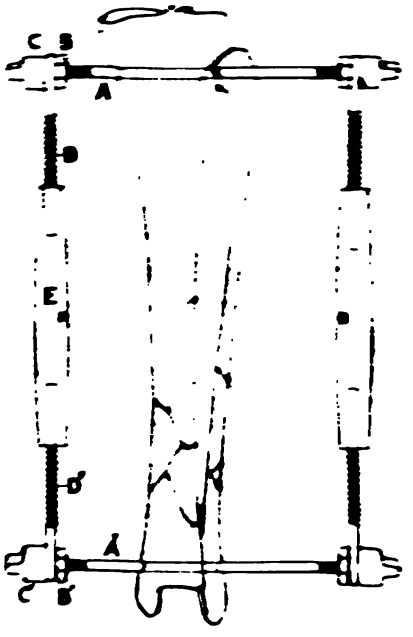


FIG. 1072.

FIG. 1073.

FIG. 1072.—Hey-Groves' double transfixion apparatus for complicated fractures of the leg bones.

A, A' = highly tempered steel bars which transfix the tibia above and both bones below. They are sufficiently long to act as springs when their ends are pushed apart. One end of each is a drill point and the other is slotted to fit a drill handle so that each is used to bore its own hole. *B, B'* = nuts screwed on to *A, A'* after insertion. *C, C'* = screw caps which protect the ends of *A, A'* and fix the apparatus rigidly when a correct position has been attained. *D, D'* = rods with eyes which slip over *A, A'* and opposite screw threads which fit into cylinder *E*.

FIG. 1073.—Hey-Groves' improved apparatus for extension and fixation.

A, Pin transfixing upper end of bone. *B*, Lateral rods which can be elongated as in Fig. 1072. *C*, Pin transfixing lower end of bone; this need not be parallel to pin *A*. *D*, Perforated iron band to surround the limb. Pin *C* passes through holes in this band. *E*, Cups fixing lateral rods to any part of the band *D* and permitting lateral movement through 30°.

"Transfix both tibia and fibula with pin A' one inch above the tip of the internal malleolus. Apply strong traction to the leg and reduce the fracture as accurately as possible. Transfix the tibia with pin A opposite the tubercle. The two pins must enter the bone by exactly parallel routes. To the affix the rest of the apparatus. Fig. 1072. By rotating the cylinders E distion is obtained. After a few days the patient can leave his bed and walk crutches, and at the end of ten days he can put his foot to the ground and

gradually bear his weight upon his injured leg. The apparatus is removed in three weeks in the comminuted cases when union is rapid, but it may be left on for six weeks in a case where union is slow."

Exact parallelism of the two pins is difficult to attain, therefore Hey-Groves has modified his apparatus, as follows: "The apparatus consists in two transfixion pins $\frac{3}{16}$ inch thick, and two longitudinal extension bars made of a tube into which screw rods $\frac{1}{4}$ inch thick threaded with reversed screws (Fig. 1073). The tube is perforated at its centre by holes for a lever, and when it is turned in one direction both the projecting bars are forced apart, whilst the reverse movement draws them together. One of the tansfixion pins passes through two holes in a circular hoop of steel 6 inches in diameter $\frac{1}{8}$ inch thick and 1 inch wide. There are twelve holes in the hoop, arranged as six opposite pairs, so that the pin can lie in any one of six different diameters of the hoop. The extension bars fit by an eyelet-hole over the ends of one pin, and by the other they take a bearing on the steel hoop by a joint which allows of a lateral movement through 30°. This point can be locked. When the apparatus is in position it permits of the following movements:

"1. Direct Extension, by rotating the central tubes of the longitudinal bars in the same direction.

"2. Tilting of the transfixion pins with consequent correction of angular deformity, by screwing one extension bar more than the other, or by screwing them in reverse directions. If the one pin which pierces the hoop lies at right angles to the plane of the extension bars, it can be tilted by pulling on one end in a distal and the other in a proximal direction.

"3. Rotation of one transfixion pin in relation to the other. This allows of rotatory displacement being corrected.

"As regards the technique of the application of this apparatus to the thigh or lower leg, the general remarks made about transfixion apply here, but in the making of the punctures for the upper or counter extension pin, the skin must be drawn downwards, whereas with the lower it is drawn upwards for the avoidance of tension.

"In applying the upper pin to the femur a point is taken on the front of the thigh vertically below the anterior superior iliac spine and on a level with the lower border of the symphysis pubis. This is over the base of the great trochanter. The pin is inserted backwards, so that its posterior end emerges behind the prominence of the trochanter and not at the back of the thigh.

"The upper pin in the tibia should lie between the level of the lower border of the patella and the tuberosity of the tibia, in a transverse direction. In each case the lower pin is in the position described above for simple transfixion.

"The apparatus is applied under general anesthesia; the double transfixion, only occupying about $2\frac{1}{2}$ minutes, can be done under gas, but unless there is any contraindication ether is better, because this gives a fuller muscular relaxation and affords time for the adjustment of the hoop and extension bars.

"Before the operation it is known by measurement or better by the X-rays exactly how much shortening exists. The longitudinal bars are twisted in their central tubular portions until this is fully corrected or until the transfixion pins show a marked bowing. Being made of higher tempered steel,

they act as powerful springs, and within two days they will have straightened themselves, and further extension can be given by a few turns of the tubular screws, and so on at two-day intervals until the correct length of the bone has been gained.

"The limb is slung up off the bed, so that the wounds can be dressed with the least disturbance. At the end of a week the patient with a fracture of the tibia and fibula can get up and the one with the fractured femur can be moved."

Method G.—Fixation by Ferrules of Decalcified Bone. (Senn.)—Figure 1074 sufficiently shows this method.

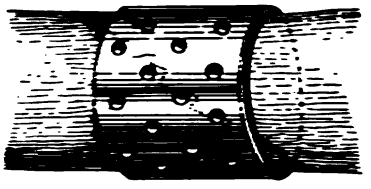


FIG. 1074.—Decalcified bone ferrule in place.

Step 4.—**Closure of the Wound.**—Have an assistant hold the limb steady in good position. Close the periosteal wound with fine catgut sutures. Close the rest of the wound *secundum artem*, with or without drainage. Apply dressings. Immobilize by plaster of Paris or preferably by proper splints. Treat as an ordinary fracture.

Early in this chapter it was stated that if the principles of treatment here outlined are carried out with cleanliness union is sure, *provided that the local and general vitality, i.e., the recuperative power, is sufficient.* Where the general vitality is low it must be stimulated by proper diet, tonics, and especially by the open air. Where the local vitality is low, although the wound may heal by primary union, yet the fracture may not consolidate, the bone-forming cells have not done their work. To stimulate repair, massage is of value and the use of apparatus which permits of ambulatory treatment may also aid.

v. Büngner ("Archiv für klin. Chir.," xli, 185) recommends that primary union be *not* sought in cases where atrophy of the fractured ends of the bone is present, but that after these structures are fixed together by any of the methods described, the wound be packed with gauze and allowed to heal by granulation. There is something to be said in favor of this suggestion.

When one bone of the leg or forearm is the site of pseudarthrosis and there is much loss of substance, this loss must either be made good or apposition of the fragments obtained by excising a portion of, and so proportionately shortening the companion bone. For example, after freshening the ends of the bone in pseudarthrosis of the tibia, direct apposition may be impossible until a segment of the fibula is excised. Where the fracture is situated in the lower third of the radius it is better to excise a portion of the distal end of the ulna rather than a segment of that bone opposite the radial fracture. By doing this the necessity of obtaining bony union of a new fracture is avoided. Such methods are easy but necessarily entail considerable shortening, hence whenever possible

the loss of substance ought to be made good by some plastic operation. The operative treatment of certain ununited fractures, such as those of the patella, olecranon, neck of femur, etc., are described in other sections of this work.

PLASTIC OPERATIONS ON BONE

Plastic operations on bone are required to stimulate union in stubborn cases of pseudarthrosis; to fill bony defects caused by the destruction or excision of segments of bone; to replace bones congenitally absent or removed by operation.

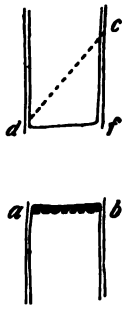


FIG. 1075.

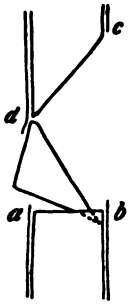


FIG. 1076.

FIGS. 1075 AND 1076.—Ollier's operation *par renversement.*

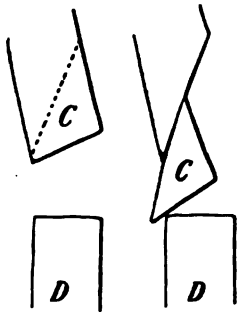


FIG. 1077.

FIG. 1077.—Ollier's operation *par glissement.*

I. Autoplasty with Pedunculated Bone Flaps.—1. *Ollier's operation par renversement* may be taken as a type of these procedures. Make an incision through the soft parts sufficient to expose the ends of the bone and the fibrous tissue connecting them. Excise the fibrous connection between the fragments. With a fine saw cut from one fragment a thin slice of bone along the line a b (Fig. 1075) and remove it. From the point c on the other fragment cut through

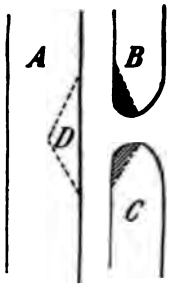


FIG. 1078.

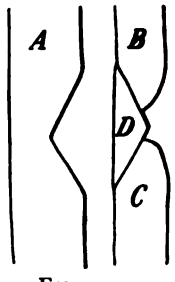


FIG. 1079.

FIGS. 1078 AND 1079.—Ollier's operation *par implantation.*

the bone along the line c d, leaving the periosteum at d undivided. The wedge of bone d c f can now be turned downwards (using the periosteum at d as a hinge) so that the apex of the wedge can be wired or stitched to the raw bone surface a b (Fig. 1076) or pushed into the medulla. In young and vigorous patients the operation has proven satisfactory. As much as two inches of bone may be replaced in this manner.

2. *Ollier's Operation par glissement.*—From one of the fragments cut the triangle C (Fig. 1077). Be careful *not* to separate this portion of bone (C) from its connections with the soft parts. Slide C downwards until it comes in contact with the fragment D, the end of which must be vivified. Suture C to D.

3. *Ollier's Implantation.*—This is only suitable when one of two parallel bones is the site of pseudarthrosis.

From the bone A cut the fragment D (Fig. 1078) preserving its connections with the soft parts. Vivify the fragments B and C. Implant the fragment D between B and C (Fig. 1079).

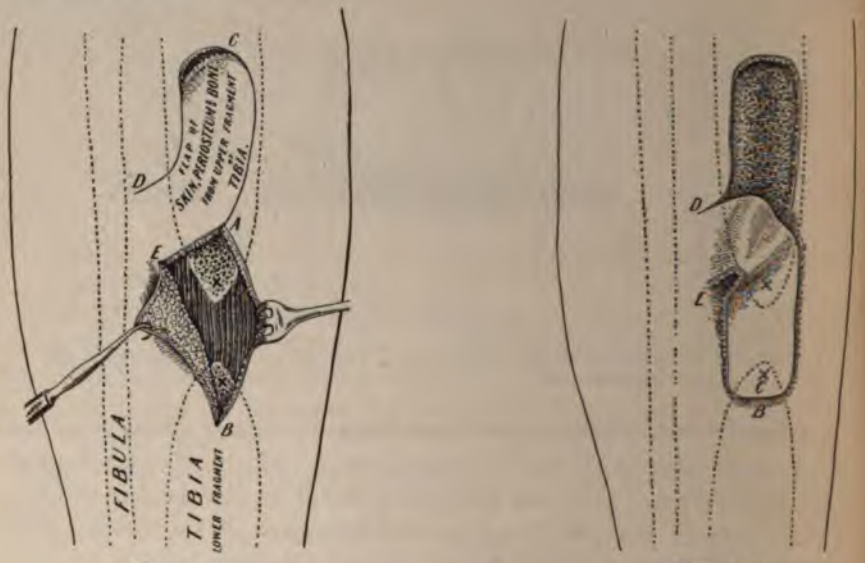


FIG. 1080. FIG. 1081.

FIGS. 1080 AND 1081.—Müller's operation.

4. *W. Müller's Operation.*—*Step* 1.—Expose the ends of the bone by a vertical incision, A B (Fig. 1080). Remove the interposed old scar tissue. With a chisel vivify the ends of the bone (xx).

Step 2.—Outline the flap D C E (Fig. 1080). With a chisel introduced at C cut a slice of bone from the upper fragment, thus forming a flap of bone, periosteum, and skin, which has a pedicle at D E.

Step 3.—Rotate the flap D C E so as to make it bridge the osseous defect. Fix the osseous surface of the flap to the vivified ends of bone fragments at xx (Fig. 1081); this may be done with sutures or pegs.

Step 4.—Close or lessen the size of the defect left by the transplantation of D E C by undermining and sliding the skin edges together or by Thiersch's grafts.

5. Müller has devised a method by which the twisting of pedicle of the flap is avoided.

Step 1.—Make the U-shaped incision A B C D (Fig. 1082), the points A and B being an inch or more above the end of the upper fragments, and the apex of the flap (C D) a similar distance below the end of the lower fragment.

Step 2.—With a chisel introduced at C D, cut a slice of bone from the lower

fragment and raise it along with the corresponding periosteum and skin. Continue the dissection of flap A B C D upwards.

Step 3.—Remove the fibrous tissue from between the two fragments of bone. With the chisel vivify the end of the upper fragment of bone.

Step 4.—With the part of flap A B C D which contains bone, bridge the defect between the upper and lower fragments (Fig. 1083).

6. *Huntington's Operation* ("Annals Surg.," Feb., 1905; "California State Journ.," Oct., 1909).—Huntington's operation is suitable in cases where there has been extensive loss of the tibia, but the fibula remains intact. It is presupposed that any infection which may have been present is now absent.

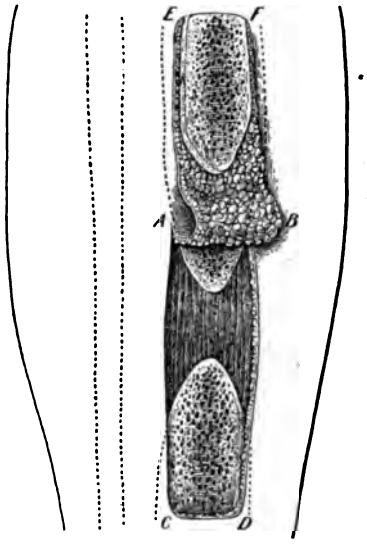


FIG. 1082.

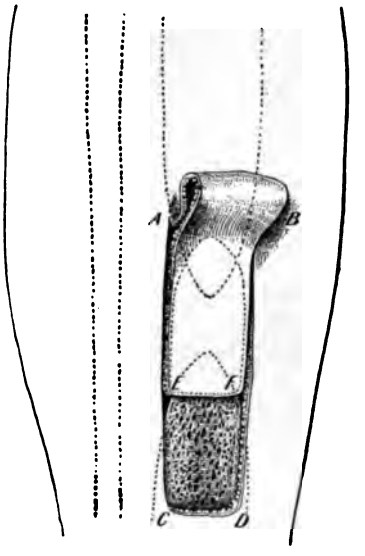


FIG. 1083.

FIGS. 1082 AND 1083.—Müller's operation.

Through an appropriate incision expose and divide the fibula at a point opposite the lower end of the upper tibial fragment and fix the fibula into a depression in the tibia. Codman ("Annals Surg.," June, 1909) carried out Huntington's operation as follows (Figs. 1084 and 1085): Make a curved incision five inches in length across the leg exposing the upper fragment of the tibia. Chisel away the tip of this fragment. Divide the fibula at a slightly higher level. Bend the leg outwards and so force the fibula into the place prepared for it in the upper fragment of tibia and push it, like a peg, for a short distance into the spongy bone. Straighten the leg. Fill the dead space left at the point where the fibula was transferred with a portion of tibialis anticus muscle. Close the wound. Dress. Immobilize. In time there is liable to be a bowing of the foot on the fibula causing a deformity.

This led Huntington after the lapse of six months to perform a second operation as follows: Expose the upper end of the lower fragment of tibia. Vivify it. Divide the fibula at about the same level. Unite the fibula to the tibia. Close the wound. Dress. Immobilize.

Several brilliant results have been obtained by Huntington's operati Huntington's patient walks without a limp—runs and plays foot-ball.

7. J. S. Stone's Operation ("Annals Surg.," Oct., 1907).—Stone's operat is practically identical with Huntington's except that he assures stability the foot in the second operation by having *both* malleoli attached to the n tibia (Fig. 1085).

First Stage.—Implantation of the upper end of fibula into upper tibi fragment. Identical with Huntington's operation.

FIG. 1084.—Before operation. FIG. 1085.—After operation.
FIGS. 1084 AND 1085.—Replacing tibia with fibula. (*Codman, Annals of Surgery.*)

Second Stage.—Expose and vivify the upper end of the lower tibial fragmen Expose (without injuring the periosteum) the lower 3 inches of the fibula. Divi the periosteum with a knife. With fine chisel and strong knife split the fibu longitudinally into two equal parts. In Stone's case "each half of the bo had a thickness of only 4 mm., scarcely over an eighth of an inch, yet in separa ing them for a distance of about 3 inches, 8 cm., it was essential that the pe osteum remain adherent to each portion and that an equal thickness of ea part be maintained throughout. It was planned to spread the halves witho breaking either. This proved impossible. Fortunately the outer rather th the inner half gave way close to the upper end of the split between them. another case it would seem wise to insure a break in the outer half at th

her than run the risk of breaking the inner half or the outer half at evel."

the fibula has been transformed to take the place of the tibia its becomes much increased so that the thin splint-like bone comes to the tibia in size.

FIG. 1086.—Tibia replaced by fibula. (*Stone, Annals of Surgery.*)

utoplasty by means of periosteal flaps (Codivilla's operation) is closely the transplantation of pedunculated flaps of bone. Codivilla, after the ends of the bone, unites them with a wire suture and envelopes re in a detached flap of periosteum taken from any convenient bone.

Codivilla is careful to remove a thin shell of bone with the periosteum, but Brade ("Beiträge zur klin. Chir.," lxi) used the periosteum alone and obtained a good result.

Operation for Congenital Absence of Tibia.

Halstead Myers ("Med. Record," July 15, 1905) operated for the above-named condition successfully as follows: Incision across the outer half of the joint opening the articulation between the fibula and femur. The patellar ligament, thin and long, was inserted on the inner side of the fibula well below its head. The capsular ligament, and especially the external lateral ligament, were very strong and required division before the head of the fibula could be drawn downwards and inwards to a position between the condyles. The patellar ligament was shortened and attached to the anterior surface of the fibula. With sutures the articular capsule was repaired so as to aid in holding the head of the fibula in its new position. After closure of the wound at the knee, the ankle was opened by a transverse incision, the external malleolus was cut off and the cut end of the fibula planted on to the surface of the astragalus, which was denuded for that purpose. Apposition of the bones was retained by sutures. The after treatment consisted in immobilization. A year after operation the patient could flex his leg to 90 degrees, almost fully extend it, and walk about all day.

II. Autoplasty with Non-pedunculated Portions of Living Bone.

A. *Transplantation of portions of bone covered with its periosteum.*

Step 1.—Expose the ends of the bone. Remove interposed fibrous tissue. Freshen the ends of the fragments. Temporarily pack the wound.

Step 2.—Select the bone from which to obtain material for transplantation, the favorite ones are the tibia, the ribs, or the upper third of the ulna. Make a vertical incision down to the bone and, without disturbing the periosteum, expose it sufficiently. With a chisel, cut away a slice of bone with its periosteum large enough to bridge the defect. Pack the wound temporarily.

Step 3.—Remove the pack from the wound made in Step 1. Bridge the osseous defect by means of the "bone-periosteal" flap. Be sure that the raw surface (cut surface) of the graft lies against corresponding raw surfaces in its new birth. If necessary fix the graft in position by means of sutures. Close the wound. Apply dressings. Immobilize.

Step 4.—Remove the pack from the wound made in Step 2. Close the wound. Apply dressings.

E. Lexer ("Archiv für klin. Chir.," lxxxv, 939) publishes a remarkable contribution to our knowledge of bone transplantation.

In his clinic amputation for dry senile gangrene is common and from the limbs so amputated he obtains his material. If the implant is to be covered by periosteum still existing around the bony defect, that covering the implant must be removed, as a double layer of periosteum gives rise to exuberant and irregular development of bone. In all other circumstances, even when the implant is placed in the medullary cavity, the periosteum on the implant should be preserved. If a tubular or cylindrical bone is used as an implant and the marrow is left intact, local and constitutional disturbances commonly give trouble without infection or interference with union. To avoid these disturb-

ances which he attributes to absorption of degenerated medullary substances, Lexer removes the marrow with a spoon and fills the resulting cavity with an iodoform plug (like Mosetig's).

Lexer has successfully implanted segments of bone (with its periosteum) 8 to 12 inches (20 to 30 cm.) in length. The bone used must be so fresh as to be still warm. See p. 900, Murphy on transplantation of bone.

If the transplants are homogenous instead of autogenous it is advisable to choose a donor whose blood belongs to the same class as that of the recipient

B. *Transplantation of part of the whole thickness of the shaft of a bone plus one of its articulating ends.*

Transplantation combined with arthroplasty.

A good example of the above is the following: In a case of sarcoma of the upper end of the humerus, Rovsing ("Hospitalstidende," iii, No. 1. Ref. "Journ. de Chir.," March, 1910) excised the diseased bone and implanted a segment of fibula.

Step 1.—Make a curved incision following the borders of the acromion process and through this penetrate the shoulder-joint. Beginning at this incision make a longitudinal cut down the outer surface of the arm to a point well below the disease.

Step 2.—Excise the desired portion of the humerus *plus* its periosteum and the muscular insertions so as to keep away from the disease. If the long head of the biceps is invqlved in the disease excise it also.

Step 3.—Attend to hemostasis and pack the wound temporarily with gauze.

Step 4.—Expose the upper end of the fibula through a longitudinal incision, being careful to retract uninjured the external popliteal nerve. Open the superior tibio-fibular articulation.

Step 5.—Mobilize a segment of the fibula about 3 cm. longer than the segment of humerus which was removed and excise it, *but leave* "a sort of muscular sheath about 1 cm. thick attached to it."

Step 6.—With a chisel sharpen the lower end of the fragment of fibula and force it into the medullary cavity of the diaphysis of the humerus.

Step 7.—With sutures fasten the remains of the articular capsule of the shoulder-joint to the fibula and the soft parts of the arm to the muscular tissue left attached to the implanted fibula.

Step 8.—Close the wound. Apply dressings.

In Rovsing's case free passive motion was possible two months after operation and the patient was able to use the arm in carrying food to his mouth.

Operations similar to or identical with Rovsing's have been performed by a number of surgeons.

CharlesDavison (Surg., Gyn. and Obst., Aug., 1919) has used the upper end of the fibula to replace the head of the femur with satisfaction. The head of the transplant hypertrophied until its size and strength met the functional demands. Immobilization was kept up for seven months. Then there was 'vigorous passive motion' until walking was permitted. Walking without support was not permitted until two years after operation. The patient (aged 50) became able to walk up and down stairs and could cross her knees while sitting.

Transplantation of Epiphysis.—In a boy, ten years old, the lower fourth of the left fibula had been destroyed two years previously. Staige Davis (Annals of Surg., 1916, Vol. LXIV, 520) freshened the distal end of the bone and cut a bed in the scar tissue which occupied the place of the external malleolus. He then exposed the upper end of the fibula, split it longitudinally and removed a fragment, with its periosteum, 6 cm. long and about ⅓ the thickness of the shaft. This fragment included the upper epiphyseal cartilage. The transplant was placed in the bed prepared for it, the marrow surface was next the tibia, the epiphysial end was used as malleolus. Free fascial strips were used to unite the transplant to the stump of the fibula and to the calcaneus respectively. A free transplant of skin was required to close the wound because of the amount of scar tissue. In spite of these handicaps the transplant lived and after five years had increased in length. Before operation the right fibula measured 20 cm., the left 22. Five years later the measurements were right 36 cm., left 32.75.

C. *Transplantation of fragmented bone with or without periosteum.* (Macewen's method.)

Step 1.—Expose the ends of the bone. Remove interposed fibrous tissue. Freshen the ends of the fragments. Temporarily pack the wound.

Step 2.—Obtain fragments of bone as in method A, or from a patient on whom cuneiform osteotomy is necessary. If there is any delay between obtaining the fragments and their implantation, be careful to keep them in warm salt solution or wrapped in warm, moist gauze. With a chisel cut the pieces of bone to be implanted into small fragments.

Step 3.—Fill the gap between the freshened ends of the bone to be united with the osseous fragments obtained as above.

Step 4.—Close the wound without drainage. Apply dressings. Immobilize. The implantation of fragmented bone has given some brilliant results.

III. **Transplantation of Dead Bone.**

A. *Decalcified Bone Chips.*—On the theory that the fragments implanted according to the preceding method do not grow, but merely act as scaffolding, to be replaced by osseous material supplied by the ends of the fractured bone, some surgeons have used in their place chips of decalcified bone. The preparation and use of decalcified bone chips is described elsewhere.

B. *Transplantation of Large Fragments of Dead Bone.*—Kausch ("Beiträge z. klin. Chir.," lxviii, p. 670) after removing the upper end of the tibia for sarcoma implanted a corresponding portion of a tibia obtained in the course of an amputation some days previously. The implant was deprived of its periosteum and marrow, was carefully boiled and soaked in ether to remove its fat. There was complete operative recovery, but recurrence of the sarcoma necessitated amputation nine months later, when examination showed the implant firmly united both to the femur and the tibia and enveloped in a new formed periosteum. Küttner ("Zentralblatt für Chir.," 1910, No. 31) excised the upper third of the femur for osteosarcoma, and at once implanted a similar portion of femur obtained from a man who had been operated on for coma due to tumor of the brain and died without regaining consciousness. The upper end of the femur along with its head was removed under aseptic pre-

ations eleven hours after death and was preserved for twenty-four hours in t solution to which some chloroform had been added. Six weeks after eration the result was promising.

IV. After removing a central enchondroma from a phalanx, Primrose im- anted an ivory peg of suitable size and shape. A skiagram taken fourteen eks later showed the peg partially absorbed but surrounded by a satisfactory ount of good bone. Primrose's operation, as well as those in which joints are nsplanted from fresh cadavera, are all anticipated in Th. Gluck's almost ophetic article published in the Archiv für klin. Chir., xli, 1890.

CHAPTER LXVIII

FRACTURES. MALUNION

When fractures have solidly united in bad position or with an excess of rmanent callus, deformity results. The deformity is often of no importance,

FIG. 1087.—Badly united fracture.
Line of section.

t when it is disfiguring, operation may be proper; when it is disabling, eration may be obligatory.

(A) When excessive callus causes injurious pressure on important nerves vessels, cut down upon the callus and with a chisel or rongeur forceps remove much of it as may be necessary. Sometimes it is wise, after freeing the nerve

or vessel from injurious pressure, to interpose a flap of fascia or muscle betwee these structures and the bone.

(B) Malunion without much shortening, but in a more or less angular posi tion, requires the same operative treatment as similar deformities due to othe causes. See Osteotomy.

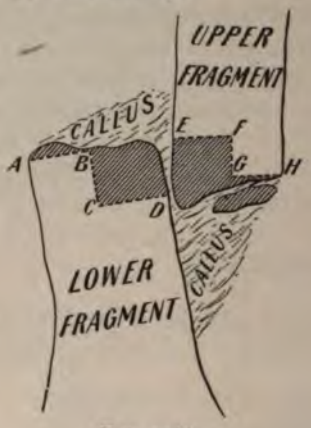


FIG. 1088.

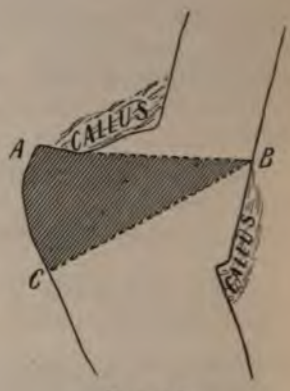


FIG. 1089.

If a moderate amount of shortening is present an oblique osteotomy will not only correct the angular deformity, but may permit the desired amount of lengthening to be obtained (Fig. 1087).

(C) **Malunion with Much Shortening Owing to "Overriding" of the Bones.**—The treatment of this condition consists in osteotomy, if necessary *plus* fixation of the bones as in pseudarthrosis. Figures 1088 and 1089 sufficiently explain the general plan of operation. It must be remembered

FIG. 1090.

FIG. 1091.—(*Payr.*)

FIGS. 1091 AND 1092.—Direct traction apparatus.

that contraction of the soft parts must be overcome before apposition in goo position can be obtained or maintained. For this purpose extension b means of the weight and pulley or suitable apparatus is often sufficient, bu

frequently be supplemented by tendon lengthening, by tenotomies, or iotomies.

ect Application of Extension Apparatus to Bones.—Codivilla and Stein- ıave each recommended that extension be applied directly to bones and ɛtter results be obtained than where the extension is exerted through ɛe plaster applied to the skin. The application of the principle is simple e provided the asepsis is perfect. There are two methods by which direct ɔn may be applied: 1. Make a puncture down to the bone. Drill a mpletely through the bone. Introduce a skewer through the bone and protrude through a puncture in the skin on the opposite side of the limb.

1092.—(*Steinmann.*)

FIG. 1093.—Improved ice-tong calipers. (*T. P. Jones, Am. J. Orthop. Surg.*)

dressings to the punctures around the protruding ends of the skewer. strings to the end of the skewer and a weight to the strings. 2. On one the limb make a puncture down to the bone through the puncture ı nail or drill securely into the bone. Do the same on the opposite side ɔone and attach weights to the nails by means of cords or calipers (Figs. ɔ91 and 1092). The first of these methods is by far the better.

sohoff uses an appliance like ice-tongs or calipers for the same purpose. Jones, Bowlby, Sinclair and others urge that the Steinmann apparatus ɛrous and that ice-tongs calipers such as devised by Ransohoff and modi- Pearson be so guarded that they grip but do *not* penetrate the bone

(Fig. 1093). Of course care must be taken to avoid any penetration of or injury to a joint in using the calipers or pins.

It may be useful to describe in some detail the operative treatment of one or two well-known examples of malunion.

I. **Malunion in Colles's Fracture.**—The lower fragment of the radius is tilted dorsally on the upper fragment and has become united there, causing the classic "silver fork" deformity.

Dawbarn's Operation.—*Step* 1.—Expose the line of union by a longitudinal incision along the outer side of the bone. Reflect the periosteum along with the rest of the soft parts from the outer side of the bone. Avoid injuring the radial nerve.

Step 2.—With a fine chisel or osteotome divide the line of union between the two fragments. Correct the deformity and after closing the wound treat as an ordinary Colles's fracture. After correction there is frequently a gap left between the two fragments. This gap may be filled in one of two ways.

Step 3.—(A) At a point midway between the wrist and elbow, make an incision down to the ulna. From the ulna excise a segment of bone equal to the gap in the radius. Unite the divided ulna *secundum artem*. The resultant shortening of the ulna permits apposition of the fragments of the radius. The whole forearm is of course shortened.

(B) Remove from the ulna a much smaller segment of bone. With the chisel cut this segment into small fragments and implant them between the fractured surfaces of the radius. The advantage of method B is that there is less shortening of the forearm than with method A.

(C) Possibly the gap might be filled by a modification of Ollier's autoplastic operation (p. 907).

Remarks.—H. A. Lothrop ("Boston Med. and Surg. Journ.," Dec. 7, 1905) finds that the deformity from unreduced Colles's fracture can usually be corrected by manipulation, under an anesthetic, during the first three weeks after injury; that after two to six months an operation on the lines of Dawbarn's should always improve the position and frequently the function; that after six months, while it is easy to correct backward and upward displacement, lateral displacement is hard to overcome and usually requires osteotomy of the ulna. The late operation, according to Lothrop, rarely improves function.

II. **Malunion after Separation of Lower Femoral Epiphysis.**—The epiphysis is usually dislocated forwards and upwards and remains in contact with the diaphysis. There may be much callus. Where fair mobility of the knee is retained or expected, operative reduction is positively indicated; where anchylosis is present an osteotomy may give as good results with less risk.

(A) **Operative Reduction.**—*Step* 1.—Expose the line of union by a longitudinal incision on one or both sides of the limb.

Step 2.—With the elevator separate the periosteum and soft structures *together* from the sides of the bone at the line of union. With the osteotome divide the line of union. By manipulation reduce the fracture. Before obtaining reduction it may be necessary to pare off some bony prominences or excrescences and to divide or lengthen the hamstrings. After reduction the

FIG. 1094.—Separation of lower femoral epiphysis, before operation.

FIG. 1095.—After operation.

fragments may be held in apposition by sutures, nails, bone pegs or buried metallic splints.

Step 3.—Close the wound with or without drainage. If a tourniquet (elastic constrictor) has been used, the author provides drainage, applies dressings and splint, and only removes the tourniquet after the patient has been put to bed with the limb fixed in a vertical position. After twenty-four hours the limb may be gradually lowered.

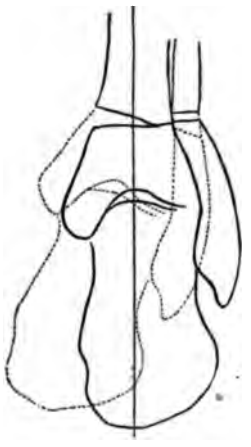


FIG. 1096.—Correction of deformity after Pott's fracture. (*Feiss, Surgery, Gynecology and Obstetrics.*)

Figures 1094 and 1095 show a case before and after the above treatment was carried out.

(B) **Osteotomy.**—When from any cause operative reduction is inappropriate, the deforming flexion may be overcome by osteotomy.

In a case of much disability due to malunion after Pott's fracture, Feiss ("Surg., Gyn., Obst.," June, 1909) corrected the deformity and restored the weight-bearing line by making a linear osteotomy on the tibia and a cuneiform osteotomy on the fibula, Fig. 1096 is self-explanatory. The result was very gratifying.

CHAPTER LXIX

SPECIAL FRACTURES

I. Fractures of the neck of the femur, whether involving the neck alone or with it the trochanter.

(A) **Excision of the Head or Fragments.**—Expose the joint by Hueter's anterior incision and remove the fragments. No special description is necessary.

(B) **Nailing the Fragments** (Langenbeck, König, Trendelenburg, etc.).—*Step* 1.—Make a short vertical incision over the outer surface of the trochanter major and expose the bone.

Step 2.—By traction reduce the fracture.

Step 3.—With a drill bore a hole through the trochanter and into that part of the neck attached to the head. Replace the drill by a screw nail or bone peg (Fig. 1097).

Step 4.—Dress. Apply traction and immobilizing apparatus. (Note: Instead of the screw nail or peg, the Parkhill-Freeman device may be used.)

(C) **Systematized Operation.**—*Step* 1.—From a point midway between the trochanter major and the anterior superior spine make an incision, 4 to 6 inches long, downwards, parallel to the outer margin of the sartorius muscle (Fig. 1098) Hueter's incision). By blunt and sharp dissection penetrate to the hip-joint between the sartorius and the tensor vaginæ femoris muscles. A few fibres of the vastus externus require division. Remember the external circumflex artery which runs transversely immediately below the trochanter.

Step 2.—Retract the soft parts. The fracture will now be visible. Note hat the capsule of the joint and its reflection over the femoral neck are torn. emove blood, etc., from the wound. If possible, by rotation of the limb xpose the capsule posterior to the joint and repair the tear in it with sutures Fig. 1099). Remember that the most important portion of capsule reflected n the femoral neck lies below the neck.

FIG. 1097.

FIG. 1098.—Hueter's incision.

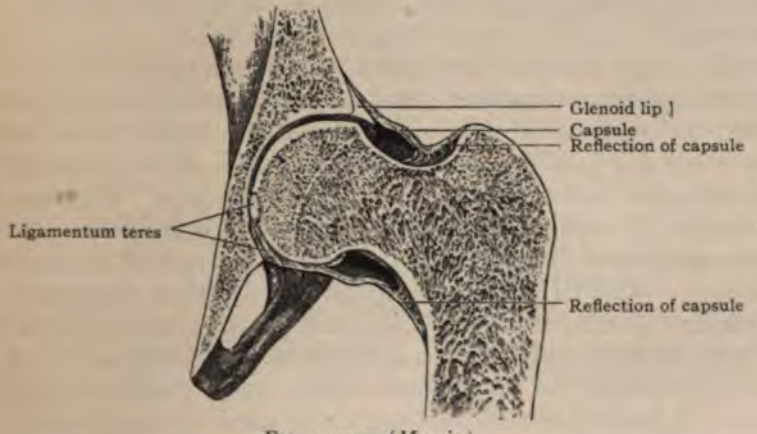


FIG. 1099.—(*Morris.*)

Bring the fractured surfaces of bone into good apposition and fix them in position (*a*) by using method B guided by the finger and eye through the open wound (*b*) by means of wire sutures.

Repair the tear in the capsule reflected on to the neck of the femur. Repair the main rent in the capsule. Close the wound in the soft parts.

Step 3.—Apply dressings. Immobilize.

J. E. Moore ("Northwestern Lancet," March 1, 1904), apropos of a case of ununited fracture on which he operated, remarks that the nail used for fixation might have been omitted with advantage and the Maxwell method of extension used alone. This suggestion applies equally to cases of recent fracture of the femoral neck whether operated on or not. The method consists in applying extension by weight and pulley in the directions shown in Fig. 1100, the resultant force being in the long axis of the neck of the femur.

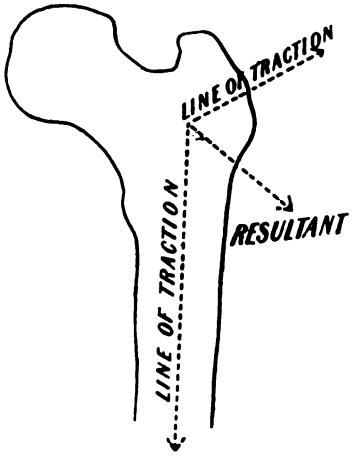


FIG. 1100.

Gurlt, Fritz König, and others have noted that in true intracapsular fracture, the head of the femur deprived of nourishment soon undergoes degenerative changes which unfit it for union even after operation, hence F. König advises operation at the end of eight days. Fractures of the neck involving the trochanter rarely require operation. Impacted fractures do not call for operation unless they cause disabling deformity. Fred Cotton in fractures of the neck of the femur produces impaction. Having placed the bones in good position by traction and manipulation, he covers the region of the trochanter with some layers of felt and then with a large wooden mallet delivers a swinging blow to the trochanter in the direction of the neck of the bone. Impaction having been secured, immobilization for six or eight weeks is practised. The author believes operation to be rarely indicated in fresh fractures of the femoral neck in the aged. Maxwell and Ruth's results of conservative treatment are most encouraging ("Journal Am. Med. Association," April 9, 1904), but considering how badly the aged bear the necessary confinement in bed, the writer prefers to trust to massage, and almost immediate passive and active motion, the result being of course pseudarthrosis, but almost always a useful limb.

If operation is chosen, which method offers most? Method B means working in the dark and entirely neglects restoration of the joint capsule which has a most important influence on the nutrition of the head of the bone. Method C is no more dangerous than methods A and B, but permits repair of capsule. One of F. König's cases ("Archiv für klin. Chir.," lxxv, 725) demonstrates admirably the importance of this step. Of course if the head of the bone is too severely injured it ought to be removed.

II. **Fractures of the Lower End of the Femur.**

(A) **Transverse Fractures.**—Operative treatment is practically the same as that for separated epiphysis.

FIG. 1101.—(*Morris.*)

a, Fat; *b*, Opening in synovial membrane behind crucial ligament leading into inner half of joint; *c*, synovial membrane reflected off crucial ligament; *d*, cut end anterior crucial ligament; *e*, post. crucial ligament; *f*, oblique popliteal ligament; *g*, quadriceps; *h*, synovial sac; *i*, tendon quadriceps; *j*, patella; *k*, bursa; *l*, condyle femur; *m*, patellar synovial fold; *n*, fatty cushion; *o*, bursa; *p*, tibia.

(B) **Separation of Lower Femoral Epiphysis.**—*Step* 1.—As the knee-joint is usually unopened by the injury, endeavor to avoid penetrating it. Figure 1101 shows the normal extent of the synovial sac. "The obstacle to reduction

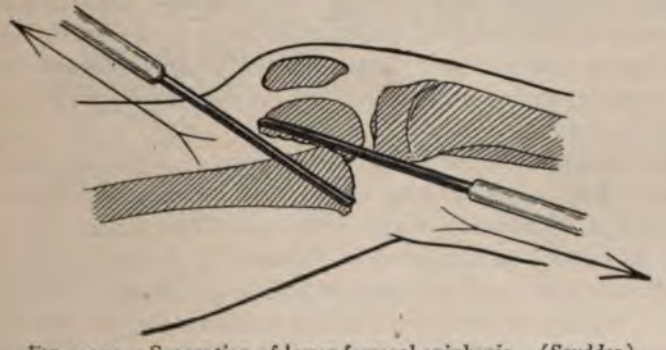


FIG. 1102.—Separation of lower femoral epiphysis. (*Scudder.*)

is no single band or obstruction, it is the retraction and tension maintained by the fascia, ligaments, and muscles of the thigh upon the tibia. This retraction is so great that the tibia is held crowded against the lower end of the upper fragment, and prevents the replacing of the epiphysis" (Scudder).

Step 2.—Make an external longitudinal incision freely exposing injured shaft and epiphysis.

Step 3.—With strong hooks make traction on the diaphysis and epiphysis (Fig. 1102) or attain the same purpose by other means. During the above manœuvre slowly flex the knee and so reduce the displacement.

Step 4.—If the fragments tend to remain in good position, pass on to Step 5. If the fragments do not tend to remain in good position apply periosteal sutures (good in any case) or bone pegs or any of the established means of fixation. It is more important to avoid irritating means of fixation in case of epiphyseal separation than in other fractures because of their possible evil effect on subsequent growth.

Step 5.—Close the wound. Apply dressings. Immobilize for three or four weeks in the flexed position. After this time the leg may be extended, but the use of plaster of Paris or splints ought to be kept up for about six weeks from the date of operation.

Figures 1094 and 1095 show separation of the femoral epiphysis before and after operation.

(C) **Fractures of the Condyles of the Femur.**—A small amount of deformity after fractures involving the knee-joint means much disability, hence operative reduction and fixation are often indicated.

Step 1.—Expose the site of fracture by an internal or external longitudinal incision. This opens the joint.

Step 2.—Reduce the fracture and fix it in proper position by some of the means already described. The author prefers bone pegs.

Step 3.—Remove any blood and detritus which may be present in the knee-joint. Close the wound without drainage.

Step 4.—Dress. Immobilize in the extended position. Elevate the limb for twenty-four hours. As soon as possible begin massage especially of the quadriceps extensor femoris. Such was the only recognized after treatment until Willems of Ghent gave in 1918 his dramatic exhibition in Paris of patients treated by *immediate active* mobilization. An account of Willems method is given on page 1030. Pierre Duval remarks "The most important result to be obtained is the reëstablishment, as far as possible, of a normal joint outline. Experience has shown that good functional results can be obtained even when there is a partial loss of joint surface if the general outline of the joint surface has been preserved."

Sampson Handley ("Brit. Med. Journ.," Oct. 5, 1912), and Alglave ("La Presse Med.," Nov. 19, 1912) both recommend transarticular exposure of the bone in so-called T fractures of the lower end of the femur. The parts are exposed as in excision of the knee by Method E, p. 1055, where the tendo patellæ is divided and an anterior flap including the patella is thrown upwards (Fig. 1103). Alglave recommends that the tuberosity of the tibia be cut from the bone by a chisel instead of the tendon being divided. It is easy to replace the tuberosity and fix it with a wire nail. Fig. 1105 shows the exposure obtained. A lateral incision plus division of the tuberosity may give sufficient excess (Fig. 1104).

III. **Fracture of the Patella.**

(A) **Subcutaneous Methods of Fixation. Barker's Method.**—*Step* 1.—Pass a long, strong, curved needle with an eye near its point through the skin and tendo patellæ immediately below the lower fragment. Guide the point of the

FIG. 1103.—(*Handley.*)

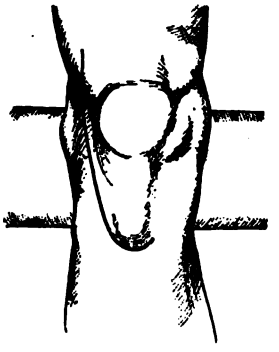


FIG. 1104.—(*Alglave.*)

needle upwards through the knee-joint, close to the posterior surface of the patella and make it emerge immediately above the upper fragment after passing through the quadriceps tendon (Fig. 1106).

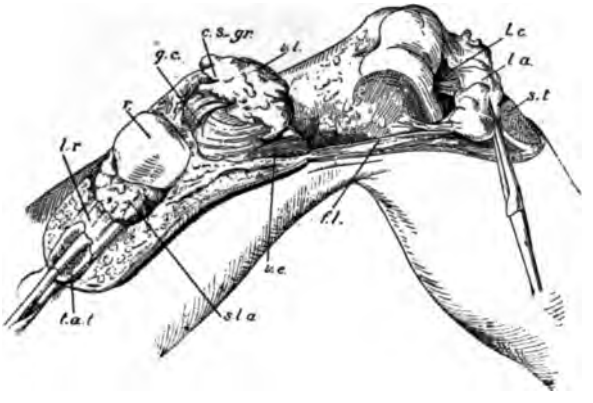


FIG. 1105.—(*Alglave.*)

Step 2.—Thread the needle with a strand of strong soft silver wire. Withdraw and unthread the needle.

Step 3.—Through the same opening reintroduce the needle and pass it **upwards** close to but in front of the patellar fragments. Make it emerge **through the same opening** above (Fig. 1107).

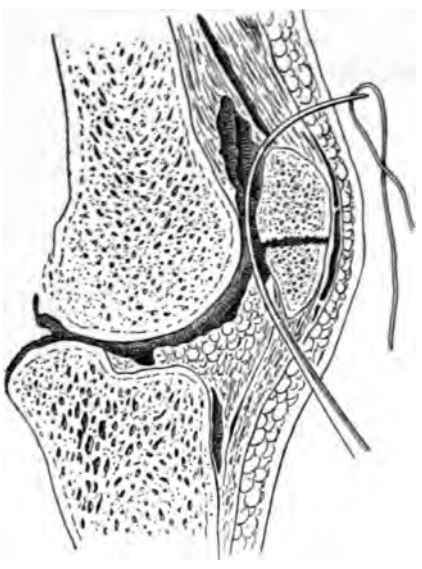


FIG. 1106.

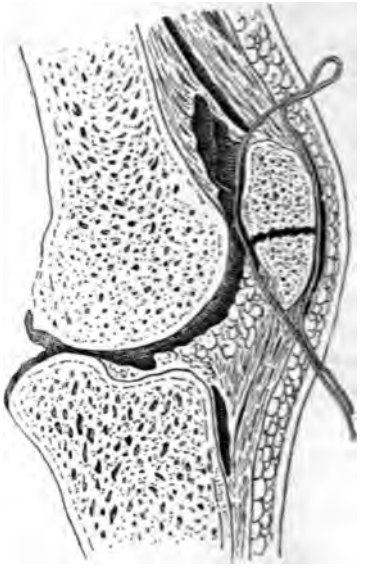


FIG. 1107.

FIGS. 1106 AND 1107.—Barker's operation.

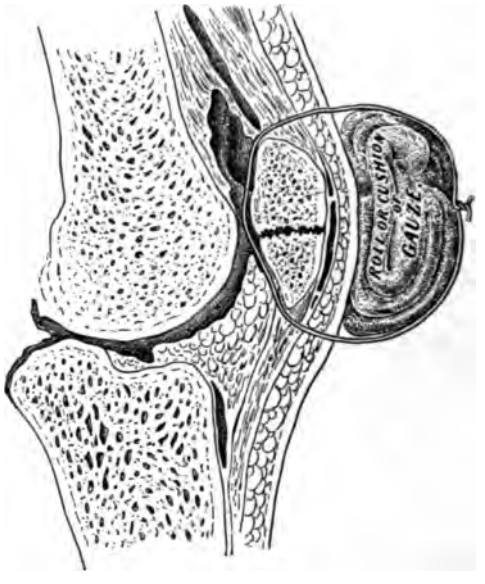


FIG. 1108.—Barker's operation.

Step 4.—Thread the needle with the end of wire protruding through the upper opening and withdraw it. The wire now surrounds the broken bone.

Step 5.—Approximate the fragments of bone. Tighten the wire and twist its two ends snugly. Cut off the excess of wire. Bury the twisted part of the wire beneath the skin, if necessary enlarging the original needle puncture for this purpose with a knife.

A modification of Barker's method is as follows: Steps 1 and 2 as above. Step 3.—Approximate the fragments of bone. Apply a firm pad over the patella. Bring the ends of the wire over the pad and twist them tight (Fig. 1108).

(B) **Open Operation.**

(1) **Classical Operation.**—*Step* 1.—Make a vertical incision in the middle line from a point about one inch above the upper fragment to a similar point below the lower fragment. Reflect the soft parts (exclusive of the periosteum which must not be disturbed) to either side as so to freely expose the fractured surfaces.

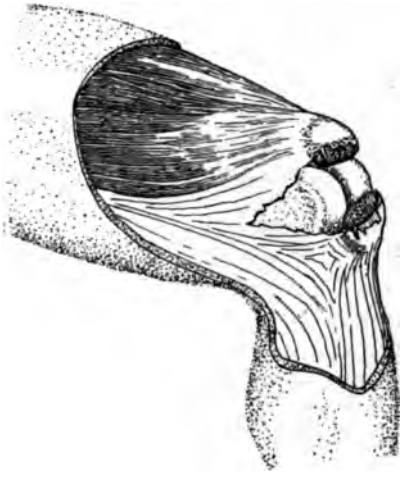


FIG. 1109.—Torn fascia impaled on spicules of bone preventing apposition of fractured fragments. (*After Helferich.*)

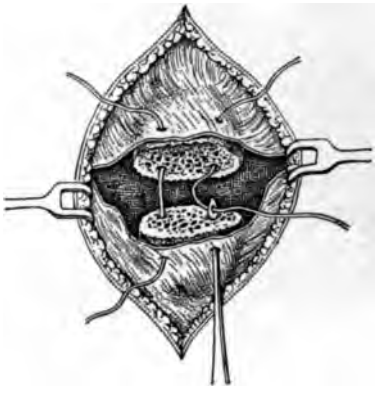


FIG. 1110.—Wiring patella.

Step 2.—Remove effused blood from the knee-joint by douching with salt solution and by gentle mopping with moist gauze.

Macewen noted ("Annals Surg.," v, 177) that the principal obstruction to bony union was tags of torn fascia and periosteum which curl in between the fragments and become fixed to the fractured surfaces by becoming impaled on the protruding spiculæ of bone (Fig. 1109). Remove all interposed tissue; in old cases of non-union this requires that the surfaces of the bone be pared or freshened with the chisel or saw.

Step 3.—With a drill bore two sets of holes through corresponding parts of the upper and lower fragments without encroaching on the articular surface (Fig. 1110), and through these pass sutures of wire or chromicized catgut. It is easy to pass wire through the holes in the bone, but when pliable material or catgut is used it is well to use a drill provided with an eye or notch near the

point by means of which the suture may be pulled into place as the instrument is withdrawn.

Step 4.—Reduce the fracture. Tighten and fix the sutures. If wire is used after it has been fixed by twisting, cut off any excess of material and by hammering flatten the projecting knot. If the case is an old one, contracture of the quadriceps may so interfere with approximation as to require lengthening of the muscle or tendon.

Step 5.—Close the wound in the soft parts. Apply dressings. Immobilize in the extended position. Elevate the limb for twenty-four hours.

(2) **Stimson's Operation. Mediate Silk Suture.**—*Steps* 1 and 2 as in classical operation.

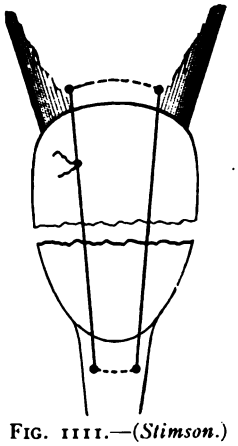


FIG. 1111.—(*Stimson.*)

FIG. 1112.

Step 3.—With a full curved needle pass a stout silk ligature transversely through the ligamentum patellæ close to the apex of the patella, then transversely in the opposite direction through the quadriceps tendon close to its insertion. Approximate the fragments (Fig. 1111). Tighten and tie the suture.

Step 4.—Place one or two catgut sutures in the torn capsule on either side.

Step 5.—Close the wound. Dress. Immobilize.

(3) **Vallas's Operation. Suture of Capsule.**—This operation is based on the fact that when the patella is fractured transversely there can be but little separation of the fragments unless the fibrous capsule of the joint (fibrous expansion of the quadriceps; capsular ligament) is also torn (Fig. 1112).

Step 1.—Expose the fracture as in the classical operation by a vertical incision. A more generous exposure may be obtained through a crucial or a transverse incision, or by reflecting a U-shaped flap of skin having its base directed either upwards or downwards. The writer has usually employed a transverse incision, but the simple vertical one is probably sufficient.

Step 2.—As in classical operation.

Step 3.—Carefully inspect the torn fibrous capsule on either

patella. If necessary trim its torn edges. With catgut close the wound in the fibrous capsule on each side of the patella (Fig. 1113); when this is done the fragments of bone will be found in apposition and no special bone sutures will be required. Suture the torn fascia and periosteum over the patella. Vallas uses the transverse incision and silver wire U-sutures for the capsule, which are removed after eight days. A glance

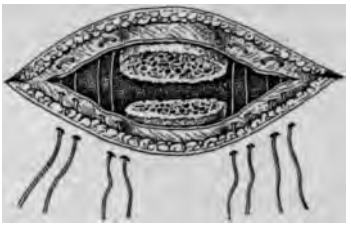


FIG. 1114.

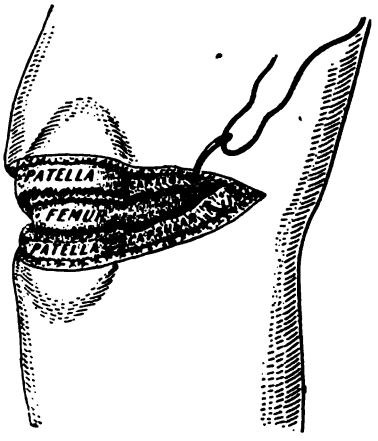


FIG. 1113.—Suture of capsular ligament.

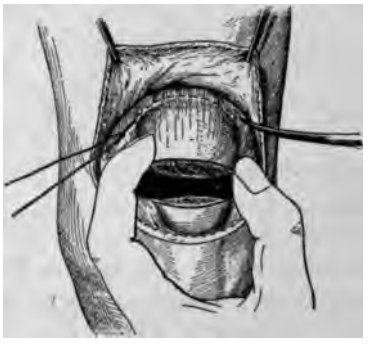


FIG. 1115.—(*Labey.*)

at Fig. 1114 shows the method of their introduction ("Rev. de Chir.," Oct., 1899). Murphy after suture of the capsule surrounds the patella with wire in the manner shown in Fig. 1117. The wire neither penetrates the bone nor the

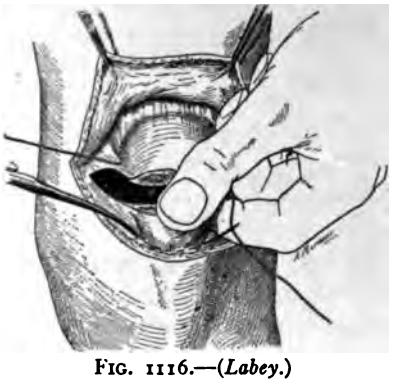


FIG. 1116.—(*Labey.*)

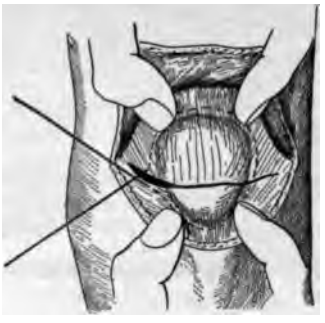


FIG. 1117.—(*Labey.*)

joint. During the whole operation no finger should touch the wound, and Murphy insists that the synovialis must not be touched even by instruments or gauze lest its endothelial covering be impaired.

Step 4.—Close the external wound. Apply dressings. Immobilize in a position of extension.

(4) **Purse-string Suture of Patella.**—Expose the bone and prepare for union as already described. With a long needle (*e.g.*, Reverdin's) make a strong silver wire encircle both fragments of the patella (Figs. 1115, 1116, 1117). Approxmate the fragments. Tighten and fix the wire by twisting. With sutures close the rent in the fibrous capsule and suture the fascia and periosteum over the patella. Close the external wound.

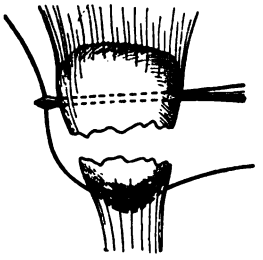


FIG. 1118.

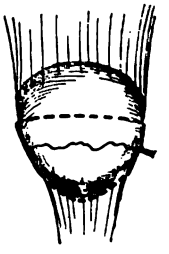


FIG. 1119.

(5) **Modified Purse-string Suture of Patella. Quenu's Operation.**—This is suitable when one of the fragments is much small than the other. Figures 1118 and 1119 sufficiently describe the method.

Fracture of the Patella with Wide Separation of the Fragments. Lister's Operation in Two Stages.—*Stage* 1.—Make a short longitudinal incision over each of the fragments (Fig. 1120, AB and CD).

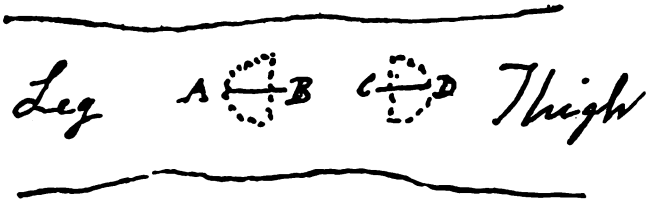


FIG. 1120.—(*Lister.*)

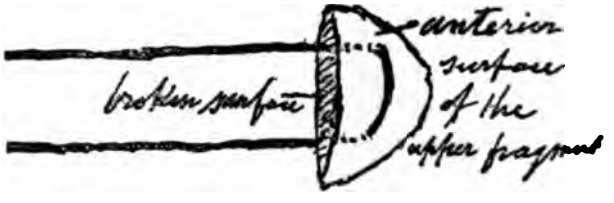


FIG. 1121.—(*Lister.*)

Step 2.—Drill two holes in the upper fragment and pass the ends of a stout wire through them from without inwards (Fig. 1121).

Step 3.—By blunt dissection make a tunnel under the skin from the incision CD to the upper one AB. Pull the ends of the wire through to emerge at CD.

Step 4.—Bore two holes through the lower fragment of the patella corresponding to the holes bored in the upper fragment. Pass the ends of the wire through these holes from within outwards (Fig. 1122).

Step 5.—Flex the thigh; extend the knee; with a strong sharp hook pull the upper fragment of the bone downwards; tighten the wire stitch and fix it by twisting. Close the wounds. Apply a posterior splint. Keep the limb elevated (in vertical position to relax the quadriceps) for two or three days. Gradually lower the limb. The object of the operation is to bring the fragments moderately close together—if this is done, the quadriceps will stretch to such an extent that at a secondary operation the broken surfaces of the patella can be freshened and brought into correct apposition. (The diagrams here used are reproductions of Lord Lister's rough sketches with autograph explanations ("Brit. Med. Journ.," April 11, 1908.)

FIG. 1122.—(*Lister.*)

Lynn Thomas attained the same end by chiseling the tubercle of the tibia from its seat, being careful not to detach the tendinous and periosteal attachments along its inner edge. Separation of the tubercle of the tibia permits the easy approximation of the fractured surfaces of the patella. If necessary the tubercle may be fixed in its new position by means of a nail.

Rotter's Operations ("Zentralblatt für Chir.," 1908, No. 17).—In a case of old patellar fracture where there was much separation of fragments and much disability, Rotter operated as follows:

(1) Exposure of the parts by means of a curved incision.

(2) Excision of scar tissue.

(3) Transverse perforation of each fragment and introduction of a wire suture. This only gave a slight degree of approximation.

(4) Formation of a flap from the aponeurosis of the rectus femoris. This flap had its base at the upper edge of the upper fragment of the patella and was long enough to reach to the ligamentum patellæ.

(5) Application of the fascial flap over both fragments of patella and suture of it to the ligamentum patellæ and to the vivified anterior surfaces of the bone fragments.

(6) Suture of the wounds in the capsule of the joint. (To the author this seems to be the most vital step in the operation.)

Immobilization for seventeen days. After eight months the functional result was good. The silver wire was found to have broken.

Occasionally the patella will be so comminuted in an open fracture as evidently impossible. Under these conditions drill and mobilize and detritus, to repair all injury

capsule of the joint, and to put the patellar periosteum and the patellar and quadriceps tendons in as favorable a condition for repair as is possible.

Indications and Choice of Operation in Patellar Fracture.—1. When the fragments are separated as much as one finger-breadth (¾ inch), operate.

2. When there is no such separation, or examination is difficult because of pain and swelling, keep the patient in bed, apply a posterior splint, treat the knee with elastic pressure and massage. After about one week, proper examination will be possible. Ask the patient to lift his heel up from the plane of the bed to the slightest extent and not more. If he can do this, operation is unnecessary; if he cannot, then operate.

3. The best time to operate is during the second week after injury. Murphy thinks that the knee should be at once injected with about 15 c.c. (℥ iv) of 2 per cent. formalin glycerine and Buck's extension applied with a weight of about 20 lbs. After the lapse of from 5 days to a week operation is safe. Arbuthnot Lane operates at once.

4. None of the subcutaneous operations permit removal of fascia from between the fragments, nor do they repair the injured and important fibrous capsule, hence they are objectionable.

5. All the methods in which material which might prevent union is removed, and in which the torn fibrous capsule is repaired, are satisfactory. The author prefers Vallas' operation.

6. When the bone is much comminuted, the purse-string suture may be the most suitable.

After-treatment.—Vallas and Murphy represent two extremes in the matter of after-treatment.

1. Vallas' advice. About two weeks after operation begin massage of the thigh. Encourage the patient to contract the quadriceps muscle, without, however, doing it to such an extent as to cause pain or jeopardize union. About three weeks after operation begin massage of the whole limb, use passive, and, later, active motion.

2. Murphy's advice. Use Buck's extension (15 to 25 lbs.) and a posterior wire trough splint. Begin passive motion in five weeks. Use a mechanical support for ten weeks.

IV. **Fracture of Tubercle of Tibia.***—When the tubercle of the tibia is torn from the bone it may be pulled upwards a distance of four inches; but this is exceptional, about two inches being the usual displacement. With the tubercle a portion of the tibial cortex may be torn off and this may remain more or less attached by its upper end to the articular surface of the bone. The fractured fragment of bone may become wedged into the knee-joint (Fig. 1123).

Operative Treatment.—*Step* 1.—Freely expose the site of injury by a vertical or, better, by a horseshoe-shaped incision having its base above. If the knee-joint is involved, wash all blood-clots, etc., out of it.

Step 2.—Reduce the fracture. To do this satisfactorily it may be necessary to pass a strong suture transversely through the tendo patellæ as a tractor.

* For a full discussion of the accident and its treatment see Gaudier and Bouret, "Rev. de Chir.," Sept., 1905.

The suture may be eventually used as a means of fixation by passing it through a hole bored in the tibia.

Step 3.—Unite the fractured tubercle to the tibia by means of periosteal sutures or of bone pegs, nails, or a wire suture (Fig. 1124). If the knee-joint is open, close it with sutures.

Step 4.—Close the external wound without drainage. Dress. Treat like fractured patella.

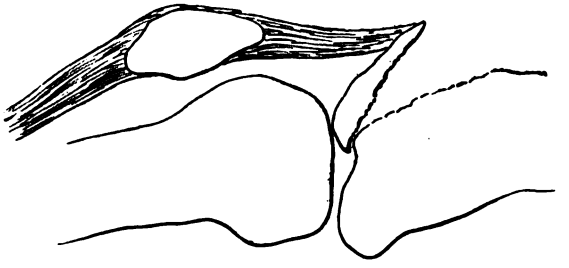


FIG. 1123.—Fracture of tibial tubercle.

V. Fractures of the external malleolus often lead to impairment of movement of the ankle-joint. This is due to the fact that the fracture opens the joint and the subsequent callus formation leads to a chronic inflammation of the joint. Bland-Sutton ("Lancet," Feb. 7, 1914) reports three cases in which he removed the detached malleolus and obtained a quick convalescence and perfect function in each. The support which the malleolus normally gives the ankle-joint is restored by a thick fibrous mass of tissue. This measure

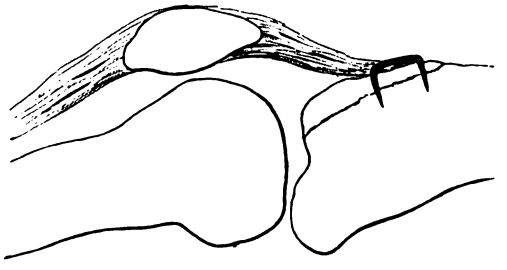


FIG. 1124.—Fracture of tibial tubercle.

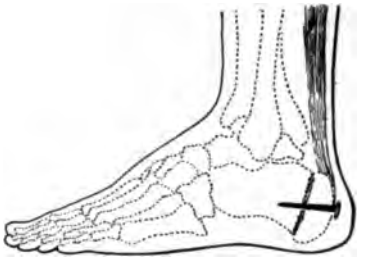


FIG. 1125.—Fracture of os calcis.

carries out a principle of Bland-Sutton's which he has long practised, namely, the removal of small fragments of the detached bone in fractures involving joints. Willems advocates immediate and persistent *active* motion.

VI. **Fracture of Tuberosity of Os Calcis.**—This fracture almost always requires fixation by operation.

Method A.—Reduce the fracture by manipulation. Make a very small incision (puncture) down to the middle of the posterior surface of the fragment of bone attached to the tendo Achillis. Drill a hole through the fragment and into the body of the os calcis. Substitute a nail or a bone peg for the drill (Fig. 1125). If necessary, close the skin wound with a stitch. Immobilize in a position of plantar flexion with the knee flexed.

Method B.—Is the same as A except that the site of injury is exposed by turning down a flap of skin, with its convexity upward. Cheyne and Burghard advise that "the flap should reach high enough up the back of the ankle to escape friction from the hard part of the boot." In old cases it may be necessary to lengthen the tendo Achillis before reduction is possible.

VII. **Fractures of the Upper End of Humerus.**—Non-impacted fractures of the anatomical neck of the humerus rarely result in bone union, because of malnutrition. If good apposition cannot be obtained (as shown by Skiagraphy) the best treatment is to excise the head of the bone through an incision along the anterior border of the deltoid. It may be well to supplement the excision by enveloping the fractured surface of the upper end of the humerus in a flap of fat and fascia so as to insure as much as possible against anchylosis. Fractures of the surgical neck and those through the neck and the tuberosities are to be treated by operation when the X-ray demonstrates the futility of conservative measures.

Occasionally the greater, rarely the lesser, tuberosity is in whole or in part detached from the humerus. Fritz König believes the accident much more common than is usually supposed as an accompaniment of luxations and of fractures through the tuberosities. To diagnose it accurately necessitates the taking of skiagraphs *before* reduction of the dislocation (Figs. 1126 and 1127). Non-operative treatment König finds very unsatisfactory.

Methods of Operating.—(A) Fracture of surgical neck; oblique fracture through tuberosities, separation of epiphysis.

Step 1.—Make a free incision in the interval between the deltoid and pectoral. Doubly ligate or displace the cephalic vein. Penetrate between the two muscles. Retract the deltoid strongly, if necessary dividing a few fibres at its insertion. Expose the fracture.

Step 2.—Inspect the fracture. Remove interposed tissues. Reduce by traction and manipulation. If the head is dislocated, it may be necessary to bore a hole in it and insert McBurney's hook as a tractor.

Step 3.—Fasten the fragments together by means of sutures (wire, catgut, etc.), pegs, nails, staples, etc., as may be convenient.

Step 4.—Suture the torn periosteum with fine catgut. Close the wound, obliterating dead spaces.

Step 5.—Dress. Treat as a simple fracture. Begin passive motion after about two and one-half weeks.

(B) **Fracture of the Tuberosity of the Humerus.**—*Step* 1.—Exposure of the fracture.

(*a*) Cheyne and Burghard recommend that a flap containing the deltoid be turned up, the deltoid being divided near its insertion.

(*b*) Make the incision recommended for fracture of the surgical neck and by retracting the deltoid expose the tuberosity.

Step 2.—Fix the detached tuberosity in place by suture or pegs. If it is difficult to insert the peg through the incision *b*, guided by the view obtained through that incision, make a puncture through the soft parts directly over the replaced tubercle and through this insert a peg or nail.

Step 3.—Suture the torn periosteum. Close the wound. Dress. Treat as nple fracture.

VIII. **Fractures of the Lower End of Humerus.**—If the position of acute on (Jones's position) be adopted for all fractures of the lower end of the erus operation will rarely be necessary. The fractures which very com-

FIG. 1126.—Fracture tuberosity of humerus. (*König.*)

FIG. 1127.—Fracture tuberosity of humerus. (*König.*)

ıly require intervention are separation of the *capitellum humeri* and fracture he internal epicondyle when there is much separation. The opinions of eons vary much as to operative interference. Cheyne and Burghard recom- d operation almost as routine in T-fractures. Of course when there is e injury to the nerves (usually the musculo-spiral and median) or to the els about the elbow and this is not relieved by reposition of the fragments one, operation is imperative.

When operating, if it is possible to avoid opening the elbow-joint, do so. Figure 1128 shows the limits of the joint. The time of choice for operation is during the second week after injury. After operation passive movements ought to be begun in about fourteen days or even less.

Methods of Operating.—(A) Fracture of one condyle.

Step 1.—Reflect a skin flap, convexity forwards, from over the fractured condyle (Cheyne and Burghard).

Step 2.—Flex the elbow. Separate the soft parts from the upper part of the condyle until there is sufficient exposure. Remove interposed tissues and wash the joint cavity with salt solution.

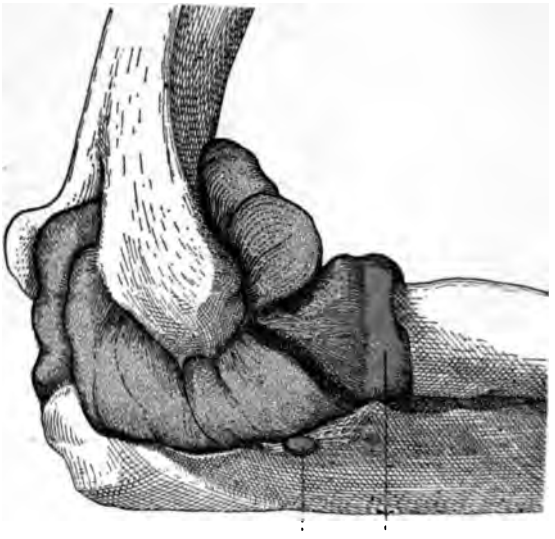


FIG. 1128.—(*Poirier et Charpy.*)

Step 3.—Reduce the fracture and fix it in position by peg, nail, or suture. Suture any important structures which may have been torn or divided.

Step 4.—Close the wound. Dress. Put up in the acutely flexed position. No splint is necessary or desirable.

(B) **Fracture of Both Condyles. T-shaped Fracture.**

Step 1.—**Method A.**—Make a longitudinal lateral incision over each condyle and expose the fracture. Do not jeopardize the nutrition of the condyle by unnecessary separation of the soft parts.

Method B.—Make a vertical median incision over the olecranon process as in excision of the elbow. Split the triceps tendon vertically. With the periosteal elevator separate the tendon from the ulna and so reach the fracture without peeling the condyle out of its attached soft parts.

Step 2.—Reduce the fracture. Peg the two condyles together or to the shaft of the humerus. If incision B has b[illegible]d, it is well after reducing the fracture to make a pu[illegible] directly ov[illegible]f the condyle and introduce the pegs through th[illegible].

Step 3.—Close [illegible]d super[illegible] Dress. Put in acutely flexed position with[illegible]

Method C.—Sampson Handley thinks that the lateral incisions (Method A) ould always be employed, because if they suffice they do little harm, and if ey do not suffice it is easy to join them by a transverse posterior cut across olecranon, and by sawing through the olecranon to gain perfect access to fracture.

(C) **Separation of Capitellum Humeri.**—Open the joint by an external gitudinal incision. Remove the fragment of bone. Close the wound. ess. Begin motion within a few days.

FIG. 1129.—(*Lambotte.*)

FIG. 1130.—(*Lambotte.*)

FIG. 1131.—(*Lambotte.*)

FIG. 1132.—(*Lambotte.*)

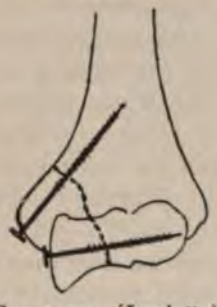


FIG. 1133.—(*Lambotte.*)

FIG. 1134.—(*Lambotte.*)

FIG. 1135.—(*Lambotte.*)

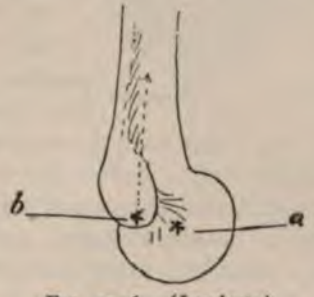


FIG. 1136.—(*Lambotte.*)

a, Point of insertion of screw into trochlea; *b*, point for nailing epitrochlea.

(D) **Fracture of Internal (or External) Epicondyle.**—(a) Make a lateral gitudinal incision over the fragment of bone without opening the joint. lace the fragment and suture it in position. The suture involves the iosteal covering or may include the cartilaginous epicondyle itself.

If the displaced fragment is very small, or if (in an old case) it has become

fixed in a position which interferes with the elbow, excise it and suture the lateral ligament in proper position. Dress. Begin motion at an early date.

The foregoing figures taken from Lambotte (L'Intervention Operatoiré dans le Fractures) show the application of screw nails to several varieties of fracture at the elbow (Figs. 1129–1136).

IX. **Fracture of Olecranon Process.**—Most cases of the above fracture call for operation.

(A) **Subcutaneous Operation. Murphy's Method.**—*Step* 1.—Make a longitudinal incision ⅓ inch long on the outer side of ulna down to the bone, ½ inch from the articular surface (A, Fig. 1137). Make a corresponding but smaller incision on the inner side (B). Between these two cuts perforate the ulna and pull a wire through the drill hole. With an appropriate needle carry the wire under the skin upwards on the inner side of the elbow and draw it out through a puncture wound at the level of the tip of the olecranon (C) the tip of the olecranon having been brought down into proper position by manipulation.

Step 2.—With an appropriate needle pass the wire through the same (upper) puncture transversely through the triceps tendon immediately above the fragment of olecranon and make it emerge through a puncture wound (D) on the outer side. Once more reintroduce the wire and make it emerge at the original incision (A). The site of fracture is now encircled by the wire.

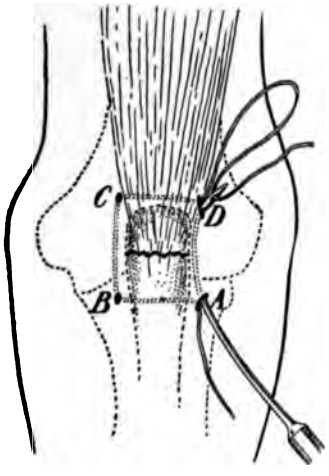


FIG. 1137.—Fracture of olecranon.

Step 3.—Tighten and twist the wire. Cut off the ends and bury the knot. Dress.

Murphy recommends immobilization in the extended position for 4 weeks, with passive motion from the third day. Cheyne and Burghard recommend that the elbow be kept at a right angle in a sling and that early motion be attempted. This advice seems very rational.

(B) **Open Operation.**

Step 1.—*Method of Exposure.*—(*a*) Make a median longitudinal incision from a point ¾ inch above the tip of the fractured olecranon downwards to a point near the base of the olecranon. Divide the skin and superficial fascia only. Reflect the soft parts to either side until the bone covered by deep fascia, etc., is well exposed.

(*b*) Make a horseshoe-shaped incision through the skin and superficial fascia from a point just below the line of fracture on one side of a corresponding point on the other side. The cut runs upwards to a point about 1 inch above the tip of the olecranon (Fig. 1138). Reflect the flap thus outlined.

(*c*) Same as (*b*) except that the base of the flap is above instead of below.

Step 2.—Examine the fractured surfaces. Remove interposed tissues. In old cases freshen the ends of the bone. If necessary cleanse the joint cavity.

Step 3.—*Suture of the Bone.*—(*a*) With a drill make one or two oblique perforations through the upp[redacted]er fragments at corresponding points.

Pull wire through the perforations (Fig. 1139). Do *not* let the deep part of the perforation impinge upon the articular surface of the bone. While boring the holes flexion of the arm permits more easy access. Now extend the arm.

FIG. 1138.

FIG. 1139.

FIGS. 1138 AND 1139.—Fracture of olecranon.

Approximate the fragments. Tighten the wire sutures and fix them by twisting. Hammer the wire knots flat or into the bone so that they may not injure the skin subsequently. Instead of wire, chromicized catgut may be used.

FIG. 1140.

FIG. 1141.

FIGS. 1140 AND 1141.—Fracture of olecranon. (*Schwartz.*)

(*b*) *Circular Suture.*—With a drill make a perforation *transversely* through the olecranon about ½ inch from the fractured surface (Fig. 1140). Pull a wire through the perforation. In the same manner drill a transverse hole through the detached portion of the olecranon and pull one end of wire above mentioned through it. Approximate the fragments. Tighten and fix the wire.

(*c*) Is the same as (*b*) except that the upper loop of wire perforates triceps tendon instead of the bone. Instead of wire, chromicized catgut be employed.

Step 4.—With fine catgut, suture the joint capsule (Fig. 1141) and the fa covering the olecranon. Close the skin wound. Dress. The limb ma immobilized either in the extended or semiflexed position or may be put sling. However dressed, passive motion must be begun very early to in good results.

Any of the methods of operating described give good results.

FIG. 1142.—Myositis ossificans traumatica. (*Keen.*)

X. **Fracture of Coronoid Process of Ulna.**—This fracture is rare and whe present is usually associated with posterior dislocation of the elbow. As th brachialis anticus is attached near the base of the coronoid, there is not muc displacement unless this part of the bone is involved. Operation must be very rarely indicated except in old cases with disability due to interferen with flexion.

Step 1.—**Exposure of Coronoid Process.**—Make a lateral incision on th or each side just in front of the condyles of the humerus. With a periosteal elevator separate the muscle from the anterior surface of the condyles unt the brachialis anticus and with it the coronoid process is exposed. Subsequen work is much facilitated if the process is exposed from both sides.

2.—Repair whatever injury is found. Usually operation is performed
ıse of disability due to excessive callus or to the formation of bone in
n of the brachialis anticus (practically myositis ossificans traumatica).
is is the case remove the excess of bone.
3.—Close the wound. Dress. Apply a sling. Begin motion early.
—The above description is based on that of Cheyne and Burghard.
ıor has never seen a case of fracture of the
process requiring operation. He has, how-
n one or more cases of myositis ossificans
ca which perhaps might have been mistaken
a condition, and in which the neoplastic
ıs removed through an external incision
ng the muscle (Fig. 1142).

Separation of Head of Radius.—Operation
ed when the head of the radius has become
l from the shaft and lies in the elbow-joint
motion.
1.—Make a three-inch longitudinal incision
. 1143. Separate the anconeus and extensor
aris muscles. This exposes the head of radius.
2.—Incise the articular capsule. Remove the
t of bone. Close the wound with deep and
al sutures. Dress. Put in sling. Begin
ery early.

FIG. 1143.—Exposure of head of radius.

CHAPTER LXX

OSTEOMYELITIS

ıe result of infection acute inflammation develops in the vascular spongy
ually near an epiphysis. Pus quickly forms and, if the patient sur-
ng enough, makes its way to the periosteum and soft parts. When
escapes, fistulæ are formed and persist. Early death of portions or
whole of the bone is a prominent feature and aids in keeping up the
ation. In time new bone is formed which incloses the dead portions
ra), keeps up the continuity of the bone, but prevents the escape of
ıestra when they become separated from the living bone by the activity
lation tissue growth.

ı the above it is evident that different methods must be taken to combat
ase according to the stage to which it has developed. When operating
omyelitis of one of the bones of an extremity, it is wise to secure a
s field by using an elastic constrictor, as it is very important to see
in order to judge how much it is necessary to do. In the succeeding
phs operations for osteomyelitis of the lower femoral juxta-epiphyseal
ll be taken as typical.

(A) **Early Operation.**—The patient, usually young, may have
slight injury or been exposed to cold; or the patient may recently h
from an acute disease; there is much prostration; pain near the
thought to be in the knee; there has been a chill and high fever ofte
for typhoid; there is evidently a serious illness, often delirium

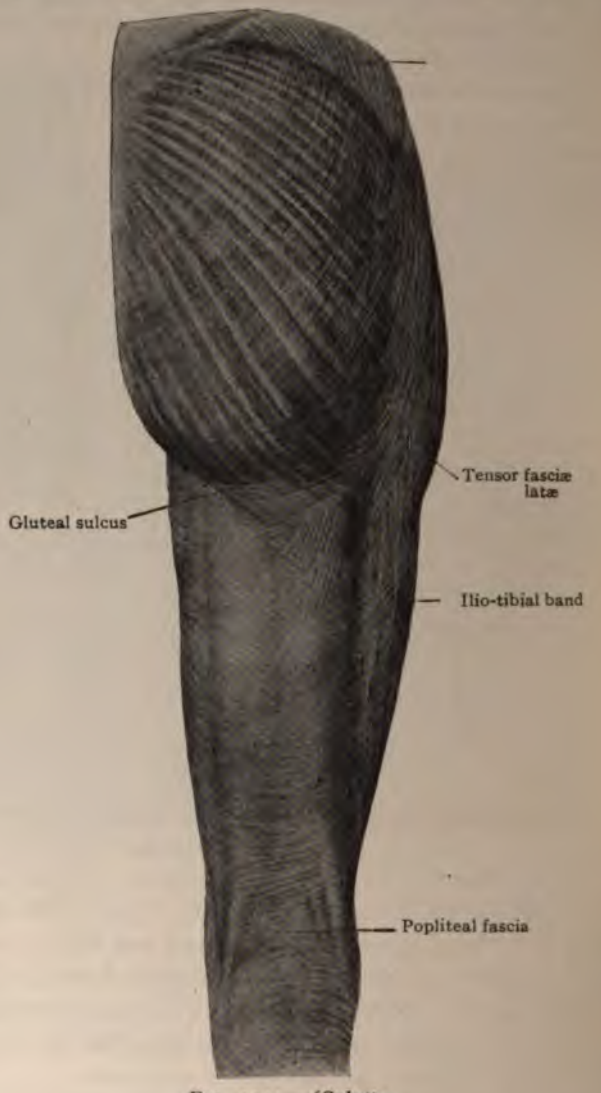


FIG. 1144.—(*Sabotta.*

Locally the only symptoms may be pain and tenderness; this last
guide to the seat of disease. Commonly at this period there is son
as well as pain.

The Operation.—Before anesthetizing the patient locate the poi
mum tenderness; this is the place to be exposed by operation.

Step 1.—Make a free longitudinal incision down to the bone o

de of the thigh as may be convenient so as to avoid injury to im-
ructures and yet reach the point of maximum tenderness as directly
. The best incision is one on the outer side situated in the furrow
he biceps tendon and the ilio-tibial band (Fig. 1144). Note the
of the divided tissues as to œdema, etc. Split the periosteum over
ted area of bone. Note the condition of the periosteum as to thick-
ess, œdema, etc., and as to the firmness or looseness of its attach-
e bone.

te the periosteum from the bone over an area about ½ inch in
Examine the surface of the bone for evidences of disease. Pass
director round the bone to the popliteal surface of the bone as pus
steomyelitis often collects here. In our example, no such evidence
scovered.

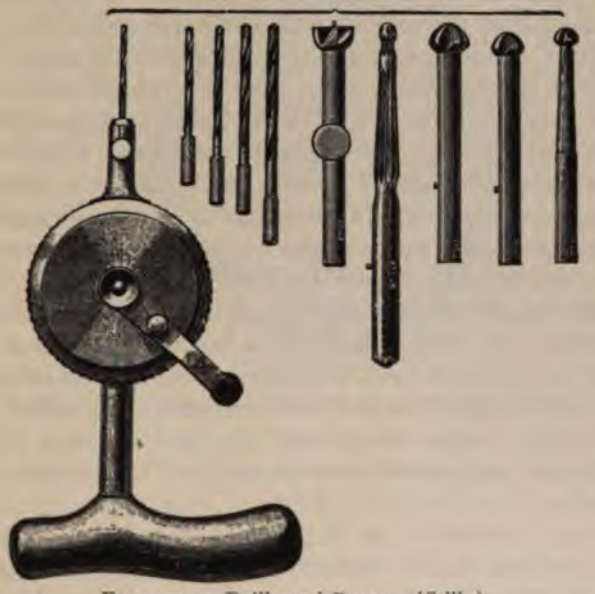


FIG. 1145.—Drills and Burrs. (*Stille.*)

.—With a Doyen burr (Fig. 1145), a small trephine, or a gouge and
netrate the bone to the medulla or into the spongy bone near the
line (a drill or gimlet is often used to penetrate the bone, but the
opening is too small to permit of proper investigation). It may
cessary to penetrate the bone very deeply as the focus of disease
ound fairly superficial. The diseased area may be recognized by
, the presence of granulation tissue, a decrease in the consistency
ue, decrease in the amount of fat, and by the presence of a small
pus.

surgeons, especially in Paris, consider that it is not possible to dis-
linically in all cases, acute suppurative osteomyelitis from periostitis
consider it harmful to systematically attack the bone since simple
incision may suffice. S. Rolando ("Zentralblatt für Chir.," 1908,

No. 20) has had much experience in hematogenous osteomyelitis and finds that the periostitis is always secondary to the osteomyelitis. To avoid unnecessarily extensive opening of the bone Rolando is guided by radiography and only opens the bone itself at places where clear zones indicate the presence of lesions. Rubritius ("Zentralblatt für Chir.," 1908, No. 9) thinks radiography valueless in recent cases. Multiple openings into the bone may be required. It is unnecessary to expose the whole of the medullary cavity as is done by some. All that is requisite is to penetrate the foci at the most dependent points possible, to evacuate their contents and to prevent reaccumulation.

Step 3.—Thoroughly remove all the diseased material with a sharp spoon, aided, if necessary, by a gouge. Wash or douche the cavity. Swab with Harrington's solution, with tincture of iodine, or with liquid carbolic acid, subsequently removed by swabbing with alcohol. If the original opening through the bone does not provide sufficiently free access to the disease or a proper amount of drainage, enlarge the opening with the gouge.

Step 4.—Provide for drainage by means of a rubber tube or, better, by a loose pack of iodoform gauze. The Carrel-Dakin method or Dichloramin T. may be employed. Partly close the external wound with sutures. Apply abundant dressings and a splint. During the operation as detailed, no focus of disease may be recognized. This does not by any means signify a mistaken diagnosis, it means either that operation has anticipated the gross appearances of disease or that the surgeon has failed to strike the focus. It is proper to make a further search for the focus of disease by drilling subsidiary holes in various directions. If, after this no focus is found, provide for drainage as described. If the operation has been performed before gross pathologic changes have arisen, the drainage provided may well lead to resolution taking place. If gross pathologic changes are present, but have not been discovered, it is almost certain that the pus will soon evacuate itself into the bone wound made by the surgeon.

Subperiosteal Abscess.—If in Step 1 pus is found situated under the periosteum, or if instead of pus inflammatory exudate is there present, are we to content ourselves with the evacuation of this focus and call the disease "periostitis"? This must be rarely necessary. Exceptionally the patient may be so weakened from absorption of toxins that the surgeon, after evacuating the superiosteal abscess and finding, on superficial examination, no evident communication with the inside of the bone, concludes that an imperfect operation will be life-saving, while a more radical operation may be left until the drainage has permitted recovery from the more urgent symptoms. Very many cures have been obtained by this imperfect operation, but it is so uncertain, and the disease is so grave that nothing short of radical intervention is justifiable in the large majority of cases. The operation ought to be carried out on the following lines:

Expose and divide the periosteum. Evacuate the pus. Scrape away all diseased tissue. Swab with Harrington's solution or with liquid carbolic acid followed by swabbing with alcohol. Examine the exposed bone for any fistulæ or crevices through which pus escapes. If the subperiosteal pus is on the

popliteal surface of the bone, retract the soft parts and examine the bone carefully with a probe. If a fistula leads into the bone enlarge it, and follow it into the focus of disease. When the fistula opens on the popliteal surface of the bone, it is often impossible to follow it, in which case the bone must be penetrated from the side (Fig. 1146). If, after thorough cleansing of the subperiosteal abscess and painstaking examination, no disease of the surface of the bone is discovered, penetrate into the bone as in Step 2 (p. 943) and proceed as there advised.

As J. C. Warren writes, "No operation which does not include an opening into the bone should be regarded as a completed one."

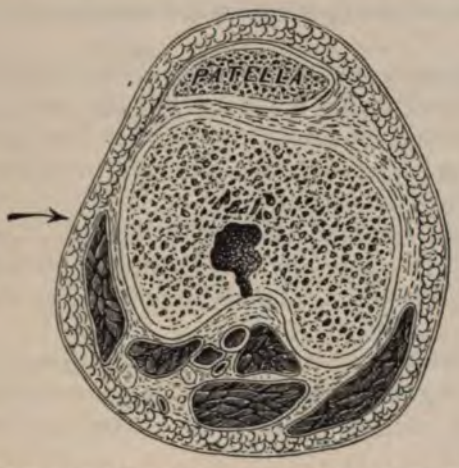


FIG. 1146.—Fistula from bone leads to popliteal space. Penetrate bone from the side.

When pus has broken through the periosteum and abscess of the more superficial structures is evident, the operative treatment must be carried out on the lines already described.

(B) **Abscess of Bone. Late Operation.**—The patient has survived the early and most acute phases of the osteomyelitis. No gross masses of bone have died, or if so, they have been destroyed. The neighboring bone has reacted against the inflammation and has surrounded the focus with a rampart of thickened and sclerosed bone through which fistulæ lead to the skin. Drainage is imperfect, but the main impediment to recovery consists in the sclerosed bone which will neither provide healthy granulation tissue to obliterate the abscess cavity, nor permit its walls to collapse. The objects of operation are (*a*) to cleanse the abscess cavity thoroughly; (*b*) to obliterate it.

These objects may be attained in more than one way.

Method A.—*Step* 1.—After applying the elastic constrictor, expose the bone freely by a suitable incision as in an acute case.

Step 2.—With a gouge and mallet expose the abscess cavity freely and clean it *thoroughly*. Dissect away the diseased lining of all fistulæ. Thoroughly disinfect as in acute cases. After the thorough cleansing, temporarily pack the wound with gauze; clean the skin around the wound; replace all soiled

towels by clean ones; discard all instruments which have been in contact with the wound up to this time; let the surgeon and assistant clean their hands or change their gloves. It is important to act as if the completion of Step 2 was the completion of the operation, the further steps being considered as a new operation performed on a clean patient, with all the appliances fresh and clean.

Step 3.—Remove the pack from the wound. With gouge and mallet cut away the sclerosed bone from around the site of the abscess, until healthy bone is reached. The object of this is to leave the cavity lined with bone from which it is reasonable to suppose that healthy granulation tissue will grow and obliterate it. The removal of the sclerosed bone is entirely analogous to the removal of scar tissue from around a vesico-vaginal fistula before closing it with sutures.

Step 4.—Loosely pack the cavity with iodoform gauze. Apply liberal dressings. If necessary, apply a splint. Put the patient in bed with the limb elevated. Remove the elastic constrictor. The author often fills the cavity with a powder consisting of iodoform 1, crystalline boracic acid 4, instead of employing gauze packing.

Often the iodoform is omitted. A warning is necessary regarding the liberal use of Boracic acid. Its use is salutary and harmless in bone cavities whereas in joints or large cavities in the soft parts absorption may cause serious or fatal poisoning.

The subsequent treatment consists in keeping the wound clean and encouraging the formation of granulation tissue. Remember that the open air, good food, good company and good amusements are the best tonics and that the patient requires such.

Method B.—Atkinson Stoney's Treatment (Brit. Med. Journ., June 21, 1919, p. 700).

Steps 1, 2 and 3 as in Method A.

Step 4.—Dry and swab the wound with ether or alcohol. Plug for about two minutes with gauze soaked in ether or alcohol. Rub into the walls of the cavity modified Bipp (iodoform 2, bismuth 1, vaseline 12). Then fill the cavity with Bipp.

(*a*) If the cavity is small and regular, if its original walls have been well removed, if there is a good depth of healthy tissue between it and the skin, close the wound with deep sutures of catgut and superficial of silk soaked in Bipp. Apply thick dressings snugly and leave them undisturbed if possible for ten days.

(*b*) It does not seem wise to close the wound. Plug the wound *tightly* with a long strip of gauze impregnated with Bipp. After forty-eight hours remove the gauze, when a dry clean cavity should be found. Fill the cavity with Bipp. Apply superficial dressings which must be changed every four or five days, fresh Bipp being put into the cavity as fast as it disappears. Never explore the cavity after the operation. *Occasionally* the cavity may be closed by operation after a week

Stoney treated 25 ca[illegible] bon[illegible]hich had lasted for periods

ranging from two months to over four years (average time after wound received was 16 months). In 22 cases (88 per cent.) the wound was healed in an average of one month and two days. Only three patients remained in hospital more than two months. A. K. and Dorothy K. Milne Henry using Stoney's method in 15 consecutive cases found only two which did not heal after a single operation.

Method C.—Use of Bone Plugs. Mosetig-Moorhof's Method ("Zent. für Chir.," April 18, 1903).

Steps 1, 2, 3, as in Method A. To remove any blood-clots adhering closely to the bone, Mosetig uses peroxide of hydrogen. After every particle of bone even suspected of disease has been removed and with it the sclerosed bone, the cavity must be thoroughly dried. For this purpose a douche of hot air is most valuable. The simplest hot-air douche is shown in Fig. 1147. The cavity is now ready to be filled.

Delbet, to test the above method, cleaned osteomyelitic cavities carefully, insufflated with hot air, curretted and then made cultures from particles re-

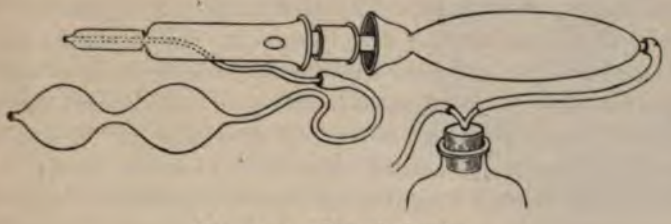


FIG. 1147.—Hot-air douche.

moved. The cultures were always positive. If he used tincture of iodine instead of hot air the cultures were negative. The hot air used had a temperature of 200°–300° but the temperature of the bone was little raised by it. Quénu is disappointed with hot-air disinfection and doubts the efficacy of tincture of iodine. Sebileau thinks the virtue of hot air consists in drying the cavity and so in permitting the adhesion of any antiseptic material to its wall. Dentists are well aware that they do not sterilize pulp cavities by using hot air but merely dry them ("Surg. Soc.," Paris, Dec. 11, 1911).

Step 4.—The following prescription has been prepared before-hand: Iodoform, 60 parts; spermaceti, 40 parts; oil of sesame, 40 parts. Heat slowly to 100° C. When the mass cools it forms a soft solid at the body temperature. Immediately before use heat the iodoform mixture in a water-bath to 60° C. to render it fluid. Pour it into the bone cavity very slowly so as to avoid the formation of air-bubbles. Fill the bone cavity completely. As soon as the mass solidifies, replace and suture the periosteum and soft parts in position. If one or more fistulæ are present, these act as drains; if such are absent, spaces between the sutures, or a strip of rubber tissue will serve the purpose. Before suturing, ligate any divided vessels which may be visible. Apply dressings and if necessary a splint.*

* A splint is required if one wishes to immobilize a neighboring joint or if, as is sometimes the case, a mere shell of bone is left full of the iodoform wax plug.

Put the patient in bed with the limb elevated and only then remove the elastic constrictor. The iodoform wax plug fills the cavity until such time as granulation tissue and ultimately bone penetrates and replaces it. Elsberg, using Mosetig's plug, has modified the method of application as follows: Remove the elastic constrictor before pouring in the plug. Gain the necessary dryness by applying adrenalin gauze. Permit the iodoform wax to partially harden outside the body and then with the fingers press bits of it into the walls of the cavity until the whole space is filled in the manner a dentist fills a cavity in a tooth.

To the writer Elsberg's modifications do not seem to be improvements.

Method D.—Is the same as Method A except that in Step 3 so much bone is removed that the soft parts can readily come into contact with the whole of the wall of the cavity left. The particulars of this method will be more fully described under Necrotomy. Various plastic operations devised to fill bone cavities will be found described elsewhere.

(C) Osteomyelitis accompanied by death of bone. Methods of operating.

Sequestrotomy. Necrotomy.—The indications for operation vary with the acuteness of the disease and with its extent. When the disease does not affect the whole thickness of the bone and the sequestrum is of but moderate size, no matter whether the disease be acute or chronic, no surgeon would hesitate to do a radical operation and do it promptly. When the disease is very acute immediate operation is imperative to prevent death from sepsis, but if the whole thickness or length of the bone is necrosed differences of opinion are permissible as to the extent of the operation. If under the above circumstances the dead bone is found separated from the living bone, in case the whole bone is affected, it is separated from the surrounding tissues, no good but rather much evil may be expected from its retention, hence it must be removed. If, however, the dead bone is not entirely free it is often the best practice to drain away all the products of inflammation but leave the sequestrum *in situ* to act as a splint until new bone has been formed sufficient in quantity to preserve continuity. Should the irritation from the presence of the dead bone keep up so much inflammation as to endanger life, or should its presence interfere with proper drainage, then it must be removed. In almost all subacute and chronic cases of extensive necrosis, it is possible and wise to delay removal of the sequestrum until sufficient new bone has been formed to maintain continuity. During this period of waiting efficient drainage must of course be provided.

In the succeeding paragraphs operations on the tibia will be generally taken as typical.

(*a*) The extent of necrosis is not great. Operate exactly as for acute or chronic abscess of the bone, removing sequestra—if loose, with forceps; if fixed, with the chisel.

(*b*) The necrosis is extensive as regards length, but enough healthy bone remains or enough involucrum has been formed to insure the continuity of the bone. The old method of treating this class of cases was to enlarge one of the fistulæ leading through the involucrum and through this to extract the

sequestrum in one or more fragments, provided it was loose; if the sequestrum was found still attached to the living bone, operation was given up until separation was complete. Such a procedure gives no opportunity to clean the dirty cavity which contained the bone and has been entirely discarded.

Typical Sequestrotomy.—*Step* 1.—Make a longitudinal incision down to the bone throughout the whole length of the disease. This incision may pass through the mouths of one or more fistulæ or may be independent of such. Denude the bone of periosteum for about ½ inch on each side of the longitudinal incision. Retract the soft parts.

Step 2.—If the sequestrum is entirely superficial remove it. If, as is the rule, the sequestrum lies inside a coffin (involucrum) of new bone, perforated by fistulæ, proceed as follows: With chisel and mallet remove enough of the new bone to give access to the whole of the sequestrum and to every part of the cavity in which it lies. Remove the sequestrum, if necessary cutting it from the living bone with the chisel or other appropriate instrument.

In removing a portion of the involucrum to expose the dead bone, if possible, do so in such a manner that the whole of one wall of the cavity is removed, the whole of the other side or wall being retained, thus after the sequestrum is taken away and the cavity cleansed the overlying soft parts may naturally fall into and obliterate the cavity (Fig. 1148).

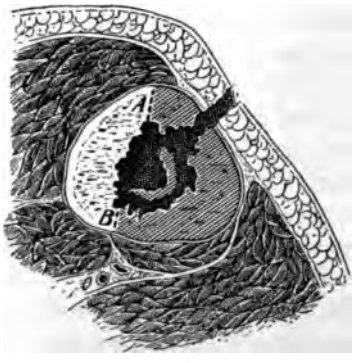


FIG. 1148.—Sequestrotomy. The bone is divided at A and B and the shaded area removed.

After removing the dead and infected portions of the bone there may be a mere splint of sound bone (cortical bone) left maintaining continuity. This quite sufficient as it will thicken and grow rapidly. As the extensive remov of bone has completely done away with the bone cavity, the soft parts can brought together and healing by first intention sought. Several differe methods of attacking the bone with a view to obliterating the cavity will described later.

While working on the bone be careful to avoid fracturing that portion the involucrum which is to be retained and on which the continuity of struc depends.

Step 3.—With the curette, aided if necessary by the gouge diseased granulation tissue and bone from the inside of the inv from any existing fistulæ. Swab the cavity with Harrington's so liquid carbolic acid (95 per cent.) subsequently swabbing with alco follows this by applying tincture of iodine. If there is any doubt plete removal of all infected tissue, pack the cavity with iodofo if the wound is found aseptic, after a few days close it with Carrol-Dakin treatment may be used. If it is believ been removed the wound may be closed at once, any

being drained, or the cavity may be filled with Mosetig-Moorhof iodoform and wax plug. The author has had very satisfactory result from filling the cavity with a powder consisting of iodoform 1, boracic acid (in crystals) 4. Even when the cavity was not above suspicion in regard to cleanliness rapid healing has ensued. After dressings are applied fix the limb in a splint. Regeneration of the bone is usually rapid.

Methods of Obliterating the Bone Cavity after Sequestrotomy.—It is assumed that the sequestrum and all diseased tissue have been completely removed, that the cavity has been disinfected and packed with gauze, that the skin around the wound has been prepared as if for a new aseptic operation, that the surgeon and assistants have prepared themselves and the instruments as if for a fresh operation.

I. **Schede's Aseptic Blood-clot.**—Remove the pack of gauze from the bone cavity. Unite the divided periosteum and soft parts with fine buried sutures in layers. Close the skin wound. Provide drainage by a few strands of catgut, a chicken-bone tube or a strip of rubber tissue. Apply abundant dressings. Immobilize the limb in an almost vertical position. Remove the elastic constrictor. Enough bleeding takes place to fill the cavity with blood. Any excess of blood is carried into the dressings. The elevated posture prevents all dangerous or inconvenient hemorrhage and may be safely discontinued after twelve to twenty-four hours. If everything progresses favorably a large cavity may heal under one dressing in about six weeks. Keep a very sharp watch for signs or symptoms of decomposition in the wound as this is liable to occur and necessitates immediate evacuation and drainage.

II. **Senn's Decalcified Bone Chips. Preparation of the Chips.**

"Select the compact layer of the fresh tibia of the ox, remove all periosteum and medullary tissue, divide into longitudinal strips about ⅛ of an inch wide and immerse in a relatively large quantity of 10 to 15 per cent. watery solution of hydrochloric acid which must be renewed daily, for from one to two weeks; then wash thoroughly in water or a weak solution of caustic potash, cut into small chips, soak for forty-eight hours in 1 : 1000 mercuric bichloride solution, remove and store in a saturated solution of iodoform in ether. When about to be used, wrap in aseptic gauze, dissolve out the excess of ether and iodoform with alcohol and put in 1 : 2000 mercuric bichloride solution until required, when careful drying with iodoform gauze should precede their implantation." (Senn.)

Remove the gauze pack from the bone cavity. Fill the cavity completely with the decalcified bone chips. Treat exactly as in Schede's method. The interstices between the chips become filled with blood. The bone chips, it is claimed, strengthen the frame-work of blood-clot into which the healthy granulation tissue penetrates, while being impregnated with iodoform they keep that drug disseminated throughout the blood-clot where it inhibits bacterial activity.

Instead of decalcified chips such foreign material as paster of Paris, amalgam and chips of fresh bone have been used with occasional success. Neuber believes the whole value of Senn's bone chips lies in the fact that they keep iodoform diffused through the blood-clot, but that the bone chips themselves

are objectionable as they are too slowly absorbed. Iodoform glycerine is valueless as a substitute because the iodoform in it is quickly precipitated. Neuber's method is as follows:

III. **Neuber's Iodoform Starch.**—Preparation of the starch. Mix 10 grams of wheat starch with the smallest possible amount of water in an open glass vessel, pour into this, constantly stirring the mixture, 200 grams of boiling 2 per cent. watery carbolic solution. After partial cooling, stir in 10 grams of powdered iodoform. Pour into a sterile glass flask. This mixture may be kept for weeks in a dark room. It is used in the same fashion as Mosetig-Moorhof's iodoform wax. Neuber considers this method suitable: (*a*) after superficial sequestrotomies and the removal of superficial tuberculous foci; (*b*) after sequestrotomies when the bone cavity is deep and large but its edges are uniform and sloping (not overhanging).

IV. Mosetig-Moorhof's iodoform wax plug has already been described.

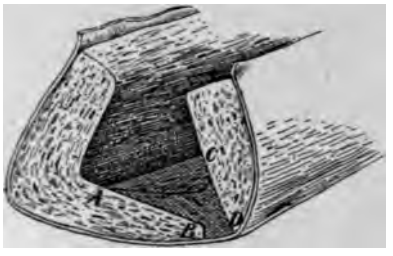


FIG. 1149.

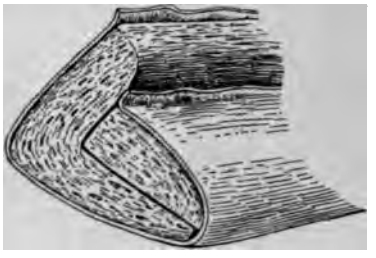


FIG. 1150.

V. Emil Beck's bismuth paste ("Journal A. M. A.," March 14, 1908) may be used in a manner similar to Neuber's starch. The formula of the paste is as follows:

Bismuth subnitrate	30.0 grams. (Carbonate?)
White wax	5.0 grams.
Soft paraffin	5.0 grams.
Vaseline	60.0 grams.

Mix while boiling. Do not spill any water into the paste while boiling. a syringe is used to insert the paste it should be sterilized by the dry process d the plunger dipped in sterile vaseline instead of water. Soft paraffin s from hard paraffin in being absorbable. Occasionally Beck adds 1 per of formalin to the paste.

number of cases of nitrite poisoning, some fatal, have been observed use of subnitrate of bismuth, it is recommended that the carbonate be used in place of the subnitrate.

cavity left after removal of the sequestrum has walls which pre-ation by the falling in of the overlying soft parts. With the chisel the bone at the base of one of the walls for the whole length of the refully avoid cutting the periosteum. Remove a wedge-shaped

strip of bone A B C D along this line of section to permit the mobilized bone to fall in and obliterate the cavity (Figs. 1149 and 1150).

VII. Osteoplastic method of M. W. af Schultén ("Archiv für klin. Chir.," lii, 145). Of this method there are several varieties, in all of these the anterior wall of the bone cavity (of the tibia) is removed, sequestra, etc., extracted, the cavity disinfected and packed with gauze for about three weeks or until it is covered with healthy granulation tissue. After being packed with gauze the wound should be partly closed with sutures to prevent too much retraction of the soft parts.

Variety a of Method (the whole shaft of the tibia is affected).—*Step* 1.—Completely remove the two lateral walls of the bone cavity in its middle third (Fig. 1151), leaving the posterior wall to maintain continuity.

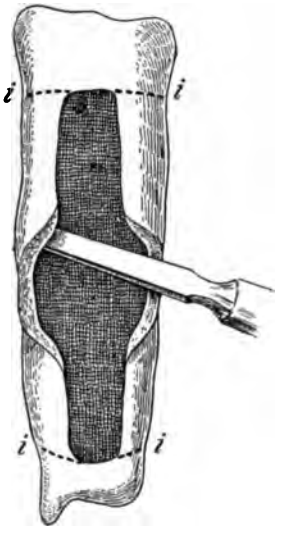


FIG. 1151.

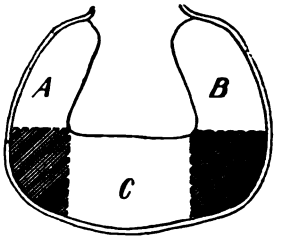


FIG. 1152.

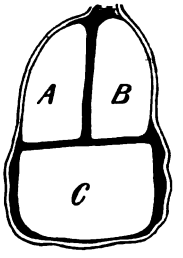


FIG. 1153.

FIGS. 1151, 1152 AND 1153.—Sequestrotomy.

Step 2.—At the upper and lower ends of the primary incision (made in the previous operation and now reopened) make transverse incisions down to the bone (Fig. 1151, i, i). Through these cuts divide the lateral walls of the cavity transversely.

Step 3.— Introduce a chisel into the bone cavity through the anterior opening made at the first operation and cut through the junction of the lateral walls (A, B, Fig. 1152) with the posterior wall (C, Fig. 1152) of the cavity. *Be careful to leave the periosteum intact.*

Step 4.—From the edge of the posterior wall (C) of the cavity or the bases of the lateral walls shave away enough bone to permit the lateral walls to slide together (Fig. 1152).

Step 5.—Approximate the lateral walls (Figs. 1152–1153 A, B) and fix them by periosteal or bone sutures as may be convenient. Close the wound in the soft parts. Dress and apply a splint.

N. B.—The object in treating the upper and lower thirds of the bone differently from the middle third is that the portions of the cavity situated at the ends of the bone are more difficult to obliterate by the falling in of the soft parts than is that part in the middle of the shaft.

Variety b of Method.—Divide the lateral walls of the cavity transversely at both its extremities and also at its middle (Fig. 1154). Mobilize and approximate the lateral walls as in variety a. Here the whole cavity is obliterated in the method used in the previous operation for the upper and lower ends. Mobilization of each lateral wall in two segments is more easily accomplished than in one, hence the transverse incision in the middle.

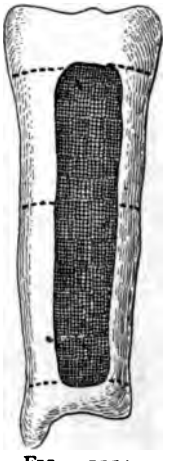


FIG. 1154.—Sequestrotomy.

VIII. **Neuber's Method of Invagination.**—Sequestrotomy has been performed, the wound has been disinfected, and all sclerosed connective tissue has been dissected away. With the chisel remove most of the lateral walls of the bone cavity, but preserve the periosteum unless it is infected. Invaginate the overlying soft parts and fix them in position by suture, pegs, or strapping. Figures 1155, 1156, 1157 explain the method more clearly than words.

IX. M. W. af Schultén's method for obliteration of cavities in lower end of femur.

Cavities at the lower end of the femur are not so amenable to the ordinary means of obliteration as are those in the tibia or the shaft of the femur. Af Schultén ("Archiv für klin. Chir.," liv, 328) advises filling the cavity with a flap of muscle and periosteum. The operation is done in two stages.

Stage 1.—This is the same as for old abscess plus sequestrotomy and need not be described again.

Stage 2.—This is undertaken two to three weeks after Stage 1. Apply an elastic constrictor.

Step 1.—With the sharp spoon remove all the granulation tissue from the wound and the bone cavity. Disinfect the cavity as thoroughly as possible. Pack the cavity temporarily.

Step 2.—Supplement the primary longitudinal incision by a transverse one involving the skin alone. Reflect the skin as in Fig. 1158, exposing the deep fascia.

Step 3.—Make the flap A B C (Figs. 1158 and 1159), consisting of deep fascia, muscle, and periosteum and having its pedicle above. The flap must be long enough and so located that it will easily fall into the bone cavity after being mobilized (Fig. 1160). (In mobilizing the flap it may perhaps be well to use a chisel instead of an elevator and so leave a thin shell of bone or some fragments of bone attached to the periosteum.) If the shape of the upper end of the bone cavity interferes with the pedicle of the flap when it is implanted into the cavity, trim the bone with the chisel until the fault is eliminated.

Step 4.—Remove the elastic constrictor. Attend to hemostasis. Remove the temporary pack from the bone cavity. Fill the cavity with the mobilized flap (Fig. 1160). Fix the flap with a few catgut sutures. Close the skin

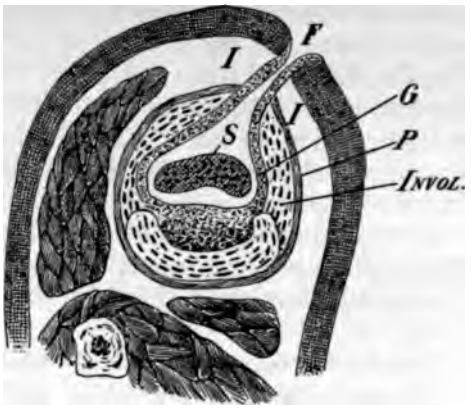
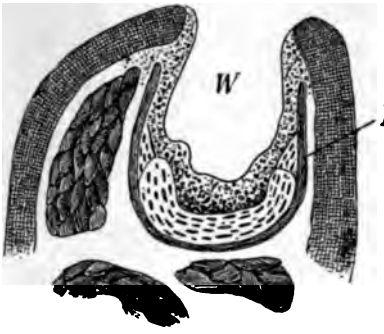


FIG. 1155.—Sequestrotomy.



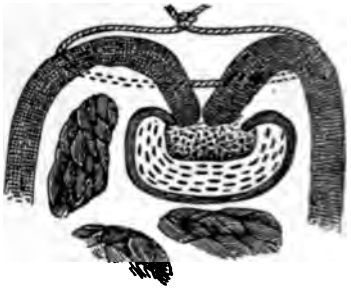
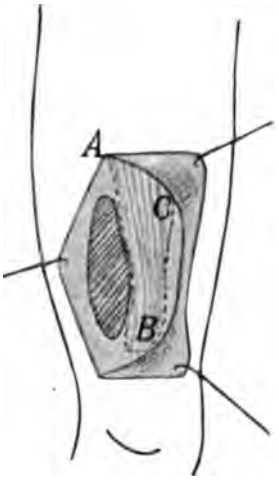


FIG. 1156. FIG. 1157.

FIGS. 1156 AND 1157.—Sequestrotomy.



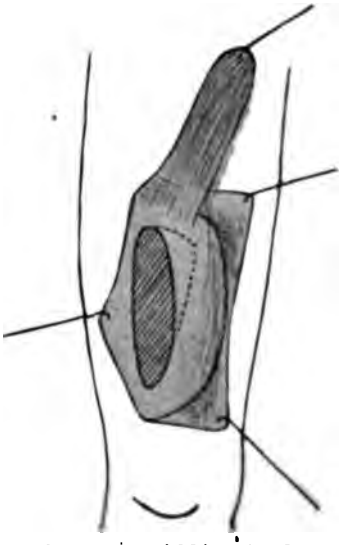


FIG. 1158.—(*Af Schultén.*) FIG. 11[illegible]

1161) wound with or without drainage. Apply dressings and a splint. the limb elevated for twenty-four hours.

Schultén considers that any pressure exerted upon the wound may ere with the vitality of the transplanted flap, hence he coveres the area wound with a wire cage over which he lays a few layers of gauze. By neans no dressings touch the wound area which is protected completely

FIG. 1160.—(*Af Schultén.*)

FIG. 1161.—(*Af Schultén*)

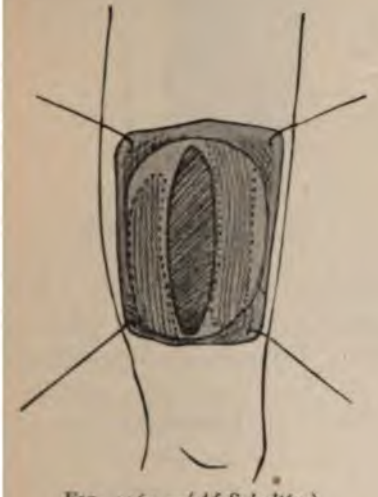


FIG. 1162.—(*Af Schultén.*)

FIG. 1163.—(*Af Schultén.*)

all irritation by the gauze covering the wire cage. The author uses a r method for the protection of areas covered with Thiersch's skin graft nds it excellent. He surrounds the area with a cushion of sterile gauze tton, like a bird's nest or ring cushion and covers the hole in the centre cushion with a few layers of gauze. This permits evaporation of dis- es and at the same time keeps away irritation. When the bone cavity

is very deep, two muscle and periosteal flaps may be used one above the other (Figs. 1162, 1163).

When the bone cavity is very long, two flaps may be used as shown in Figs. 1164, 1165. Similar procedures may be applied to the obliteration of cavities in other locations.

(*c*) The whole or almost the whole shaft of the bone is necrosed, the periosteum is almost entirely separated from the bone and between these two structures there is much pus.

As already mentioned, if efficient drainage can be maintained, it is wise to retain the sequestrum as a splint, especially as many cases are known in which partial regeneration of the apparently dead bone has taken place. If, however, in spite of free drainage symptoms of intoxication persist the dead bone must be removed. If a disk of healthy bone is left between the shaft and epiphysis

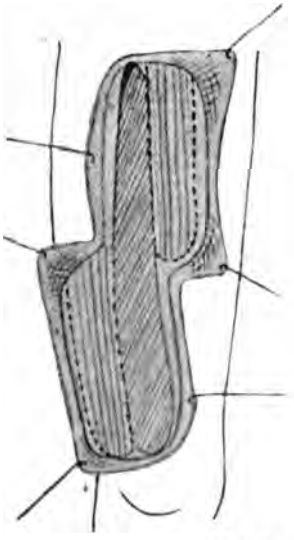


FIG. 1164.—(*Af Schultén.*)

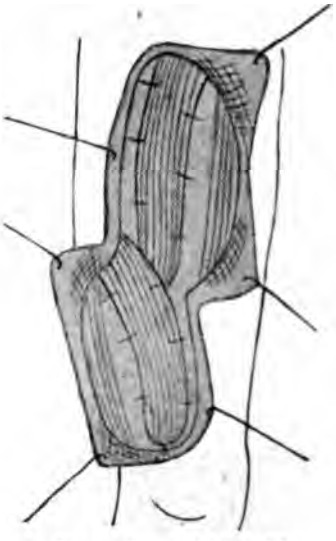


FIG. 1165.—(*Af Schultén.*)

no deformity from shortening need be anticipated (G. B. Johnston). When the tibia, for example, is removed its companion bone, the fibula, takes on compensatory hypertrophy. G. Ben Johnston ("Transactions Am. Surg. Assoc.," xxii) thus describes the operation:

"(*a*) Free incision and complete removal of *all* diseased bone.

"(*b*) Spare all periosteum possible.

"(*c*) Avoid curette, or use cautiously.

"(*d*) Purify the wound by the strictest antiseptic methods.

"**After-treatment.**—(*a*) Maintain aseptic methods.

"(*b*) Avoid too frequent and rough dressings.

"(*c*) Treat as a fracture by immobilization in a fracture box.

"(*d*) Carefully shape the parts, as bone tissue develops, by bandages or adhesive straps.

"(*e*) Protect the young bone [illegible] plaster of Paris.

"(*f*) Abstain from the use of the limb until the new bone is capable of sustaining the weight of the body.

"(*g*) Look after the general health."

Le Conte ("Trans. Am. Surg. Assoc.") takes up a very similar position supporting it by the experience of himself and his colleagues in the Pennsylvania Hospital of Philadelphia.

X. Von Eiselsberg's method. Treatment of large defects in tibia. Von Eiselsberg ("Archiv für klin. Chir.," lv, 435) extended the König-Müller method of closing cranial defects to the treatment of large defects in the tibia. While the method was devised to repair the damage done by the removal of a sarcoma, it may be employed to rectify defects from other causes, *e.g.*, from total necrosis of a long segment of the bone.

Step 1.—Apply an elastic constrictor. Clean and vivify the defect to be filled. If very little of the lower end of the tibia remains it may be removed and a portion of the astragalus vivified for the reception of the flap.

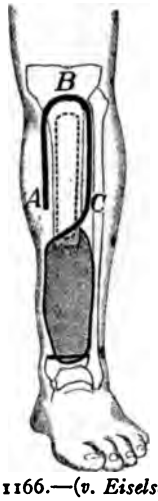


FIG. 1166.—(*v. Eiselsberg.*)

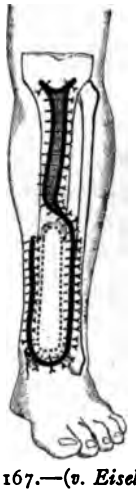


FIG. 1167.—(*v. Eiselsberg.*)

Step 2.—Divide the skin so as to make the flap A B C, Fig. 1166. With a chisel make an incision through the whole thickness of the cortical bone along the dotted line in Fig. 1166. *Do not in any way* separate the soft parts from the bone within the encircling bone incision. With the chisel separate the divided cortical bone, in one piece with the periosteum and skin, from the medullary bone. This gives us a flap of skin, periosteum, and cortical bone provided with a pedicle at A.

Step 3.—Twist the flap into position to fill the tibial defect (Fig. 1167). Suture it in position. Do *not* apply too much torsion to the pedicle, and when applying dressings do not let them exert much pressure either on the pedicle or on the flap.

Step 4.—Close the wound left on the upper part of the leg by sliding the skin over the osseous wound. Complete closure will often be impossible, but the resultant space may be subsequently covered by Thiersch's skin grafts.

Step 5.—Apply dressings and a splint. Place the limb in a vertical position.

ve the elastic constrictor.

CHAPTER LXXI

TUMORS OF BONE

I. **Benign.**—Removal of the neoplasm itself is usually all that is necessary for a cure. If the tumor involves so much bone that, after its removal, restoration of the continuity of the limb becomes impossible or inadvisable, then amputation may be necessary.

Simple cysts of the long bones have no connective tissue capsule, but islands of cartilage may exist in the bony capsule. They should merely be curetted and drained. R. C. Elmslie (Brit. Journ. Surg., II, No. 5), speaking of benign cysts (osteitis fibrosa) of the humerus, advocates thorough curettement, and opening of the medullary cavity above and below so as to admit normal marrow into the cavity. "If there is any deformity, the humerus may be safely broken or cut through at the site of the cysts in order that the bone may be straightened." Ordinary dentigerous cysts merely require evacuation of their contents, removal of their membranous lining and excision of just so much of their bony wall as will correct deformity. Adamantine epitheliomata (Bloodgood) differ from dentigerous cysts in containing white granular tissue. Such a tumor must be excised *with* its bony wall, but it is permissible to keep close to the tumor. This tumor is included among the benign neoplasms merely because it is indistinguishable clinically from a dentigerous cyst and if excised as above it does not tend to recur. Osteomata should be removed thoroughly along with considerable of their bony basis. The same is true regarding enchondromata.

II. **Tumors of a Low Grade of Malignancy.**—Many of the tumors referred to can scarcely be recognized before being exposed or incised.

Giant-cell Sarcoma. Myelogenous Sarcoma. Myeloid Sarcoma.—When cut into, the tumor presents a peculiar brownish-red color like liver or spleen. It is very vascular, hemorrhage into it is common, it is friable and can be broken up into irregular masses. The tumor usually grows in the medullary cavity of the long bones and is surrounded by a shell of new-formed bone. It is only locally malignant, in its earlier stages at least, and generally grows slowly without much pain, causing a gradual and uniform expansion of the bone. In time the tumor extends beyond the bone and invades the soft parts and must then be considered distinctly malignant.

In its early stages a giant-cell sarcoma may be treated by excision of the tumor and the surrounding bone. W. Kramer writes ("Archiv für klin. Chir.," lxvi): "It is only during the operation that the surgeon can come to a conclusion as to the propriety of conservatism. In my two cases I have not been afraid to ascertain the condition of the marrow by an exploratory evidement of the remaining bone and have only procecded to unite the ends of the bone when that has been found normal." J. C. Bloodgood ("Journal A. M. A.," Feb. 1, 1908) writes of giant-cell sarcoma: "It may be as slow

growth as the cyst. The X-ray shadow does not distinguish it positively om any other medullary tumor having a bone shell. This tumor has been ermanently cured by simple curetting. Recurrences have followed curet-ng, but were permanently eradicated by a second operation of curetting esection, or amputation. Of over one hundred cases of the pure tumor none as given metastasis. It seems justifiable at the first operation, therefore, attempt the most conservative method, even with the risk of a local recurrence hich, if it does occur, apparently is not associated with any danger of metas-sis. One should not attempt curetting unless there is a thick shell of bone, so at the curette or chisel removes a zone of bone beyond the tumor. When the ell of bone is thin, subperiosteal resection should be performed; when the riosteum and surrounding muscles have become infiltrated, total resection indicated. In one of my recorded cases in which a cure was effected and which there was infiltrated muscle, the microscope demonstrated the giant-ll tumor within a few millimetres of the plane of resection. For the periosteal ant-cell tumor local resection with chiseling of a zone of bone beneath is fficient."

O. Hildebrandt believes the local removal of myeloid sarcomata gives certain results and is not advisable.

Sir H. Morris removed the radius and ulna for a myeloid sarcoma originat-g in the former and firmly attaching the ulna to it. After four years there as no recurrence. Clutton operated on three cases of endosteal sarcoma the radius. In one of these the sawed end of the bone showed a small odule of tumor in the medullary canal; after this was removed by scraping nd gouging a cure seems to have been obtained. In another case where the ead, neck, and upper end of the radius was excised there was no recurrence hen the patient died from renal disease after eighteen months.

Herten ("Zentralblatt für Chir.," Feb. 5, 1910) reviews the cases (60 in ll) of sarcoma of the long bones operated upon in the Breslau clinic between 890 and 1909.

Amputation or exarticulation was performed in advanced cases when the arcoma did not seem suited for resection. (Twenty cases of periosteal sarcoma; ix of myelogenous, central and chondro-sarcomata.)

None of the periosteal sarcomata were permanently cured while there was o recurrence in two cases of myelogenous sarcoma, in one of central round ell sarcoma, and in one of unknown variety. Of twenty-nine resections ve were too recent for consideration; of the remaining twenty-four, twelve ere periosteal, twelve myelogenous, central and chondro-sarcomata. One the periosteal remained cured, *but only after* amputation because of poor trition of the limb and reamputation because of recurrence one year later. the group of myelogenous and central sarcomata nine were cured and ree died.

Among the nine which remained well, four required amputation subse-ently, but in five the resection sufficed.

Among the twenty-nine resections, recurrence was recognizable eight mes and in eight cases amputation or exarticulation was necessitated owing recurrence or to want of consolidation.

Herten concludes that a high amputation or exarticulation is always indicated in periosteal sarcoma of the long bones, while in myelogenous, central and chondro-sarcoma resection is proper in favorable cases. In one case where a central round cell sarcoma of the humerus was resected there was no recurrence until after the lapse of five years when "suddenly within six weeks there was a recurrence the size of a head."

Küttner disapproves of conservative operations in periosteal sarcomata, prefers amputation even in myelogenous sarcoma and thinks resection only justifiable in very favorable cases.

On the whole, one may conclude that a conservative operation is proper for the thorough excision of giant-cell tumors affecting bones which are of prime importance for the efficiency and comfort of the patient. Examples of such bones are the femur, the humerus, the radius or ulna, the jaws, etc. When a toe, finger, foot, or perhaps even when the tibia is the site of the disease, amputation may leave the patient as capable or more capable of pursuing work or pleasure and gives a better assurance of real cure. The amputation ought, however, to be conservative and not such as is described later in this chapter.

Pure myxomata of bone (endosteal or periosteal) are rare. Treatment is the same as for giant-cell sarcomata.

III. **Malignant Tumors.**—Sarcomata (round or spindle cell, angio-sarcoma) are the malignant neoplasms which occur primarily in bone. These tumors (whether central or subperiosteal) early pass beyond the limits of the bones and infiltrate the muscles and tendons attached to them. The muscles act as an excellent path for the conduction of the infiltrating neoplastic tissue from one bone to another, *e.g.*, the deltoid may conduct neoplastic tissue from the humerus to the scapula. This is important from the standpoint of treatment. Metastasis is very common in spite of treatment. A classical rule in the treatment of sarcoma of bone was to amputate at or above the joint proximal to the disease, *i.e.*, to remove the whole of the bone affected. This treatment ought to be effective if the tumor is still confined within the bone; if, however, muscular infiltration has taken place, even if it is not apparent to the naked eye, then the only hope of benefit lies in more extensive work. *Theoretically* to achieve the best permanent results one should remove the bone primarily diseased, the muscles inserted into it and the bone from which these muscles arise. This theoretical aim is nearly attained in the cases of tumors of the humerus by interscapulo-thoracic amputation. The accompanying statistics speak for themselves. Berger. Forty-six cases. Primary mortality, 5 per cent. Free from recurrence after one year, 33 per cent.

Könitzer. Primary mortality, 4 per cent. Known recurrence, 21 per cent. Free from recurrence in less than one year, 34 per cent. Free from recurrence longer than one year, 21 per cent. Untraced, 24 per cent.

The same principle may be easily carried out in sarcomata of the foot by amputating above the knee. Unfortunately, in many or most instances practical considerations (primary danger, unendurable deformity, etc.) prevent the attainment of the ideal. Under these circumstances one may amputate as

high as possible and at the same time remove as thoroughly as possible the muscles inserted into the diseased bone, especially those most likely to be involved. *Example:* Periosteal sarcoma on the *outer* side of the head of the tibia. Amputation above the knee is necessary. It is probable that any neoplastic invasion of the tendo patellæ will be slow to spread upwards *beyond* the patella; hence if the disease is tolerably recent the quadriceps extensor may be considered reasonably safe. The biceps is the muscle most probably involved, hence as soon as the amputation is completed and the main vessels ligated it seems to the writer most reasonable to expose this muscle throughout its whole length and to excise it completely.

Carcinomata and hypernephromata are always secondary to disease elsewhere, and any operation performed on them must be considered merely palliative, except when the primary tumor has directly invaded the affected bone and and can be removed with it.

Wengloski (Lancet, May 16, 1914) in sarcomata which involve a bone removes the disease of the soft parts, scrapes away the rest of the tumor upon the bone and lays bare the bone as if for resection. He then covers the soft parts with three or four thicknesses of gauze, covers the gauze with asbestos paper and the paper with sheets of metal. The metal is to keep condensed steam from the asbestos.

Steam is generated in an autoclave or even a kettle (the steam is under a pressure of from 3 to 5 atmospheres). A thick rubber tube about 6 feet long conducts the steam from the spout of the kettle to a metal nozzle. For the front of the bone a straight metal tube with terminal holes (like the 'rose' of a watering pot) is good. For the hinder surface of the bone a flattened curved tube with holes on its concave face is requisite. Through one or both of these tubes steam is applied to the exposed and diseased bone so as to kill but leave it *in situ* like a graft of dead bone.

Experiments show that when steam is applied to the surface of the femur a thermometer in the medullary cavity registers from 75° to 80° C. (167° to 176° F.) in from 4 to 4½ minutes. To gain the same result in the condyles of the femur takes 8 minutes; in the tibia, 3 minutes; lower jaw, 1½ minutes. The effect of the steam spreads only about 2 cm. (¾ in.) upwards or downwards along the bone from the site of application; thus if much of the length of the bone is to be sterilized it must be done bit by bit, the nozzle being moved along the bone. The results of Percy's operation on cancer of the uterus seem to show that moderate heat is fatal to malignant cells and to support Wenglowski's ideas.

CHAPTER LXXII

CHONDRECTOMY

It is well known that when osteomyelitis affects an active (fertile) epiphyseal cartilage one of two things may happen: (*a*) The cartilage may be destroyed and as a consequence growth of the bone cease. (*b*) The cartilage may be stimulated and growth of the bone become excessive. Where the diseased epiphyseal cartilage is that of *one* of the bones of the forearm or leg, deformity results because of the unequal growth of the two bones. The deformity may be treated by resecting a segment of the longer bone, thus shortening it. Ollier has operated in a more scientific fashion. He cuts down upon the epiphyseal cartilage whose active growth is producing the deformity and destroys it in part or completely. In the forearm bones the fertile epiphyseal cartilages are at the inferior extremity of the bones; in the tibia the fertile cartilage is superior.

CHAPTER LXXIII

OSTEOTOMY

SPECIAL INSTRUMENTS REQUIRED

1. **Chisels.**—Although for many purposes the ordinary carpenter chisel, *tempered to cut hard wood*, is convenient and efficacious, yet most surgeons prefer an instrument fashioned out of one piece of metal; of these there are innumerable patterns. All chisels ought to be large enough to afford a good grasp to the surgeon's hand; such as are so small as to require handling by

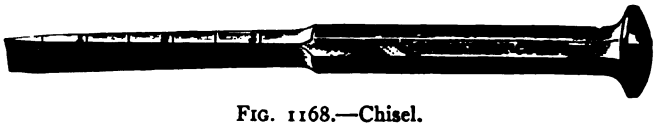


FIG. 1168.—Chisel.

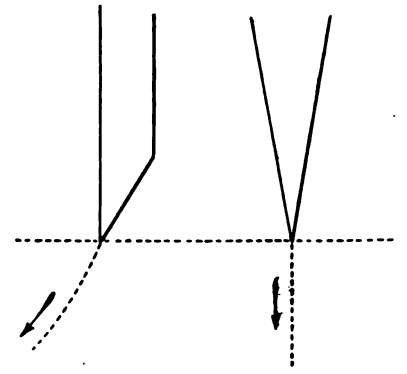
the fingers and thumb are difficult to use with precision. The most useful chisel has a cutting edge ½ inch wide; a narrower instrument is also serviceable.

Chisels are of three varieties:

(A) The ordinary chisel with beveled edge. This is suitable for paring or shaving bone and for excising wedges of bone. Figures 1168 and 1169 show why ordinary chisels are not fitted to make linear incisions in bone.

(B) Gouges of various shapes are useful especially for the cutting of gutters or grooves in bone. Their cutting-edge should be beveled on the convex or outer side (Fig. 1170).

C) **Osteotomes,** or wedge-shaped chisels, are the only chisels suitable for ing a clean cut into or through a bone. Macewen's osteotomes, in three (Fig. 1171), are classical and efficient. Various surgeons have modified ewen's osteotomes, but only in non-essential details.



Chisel. Osteotome.

FIG. 1169.

. **Mallet.**—A mallet is a necessary adjunct to the chisel. Wooden mallets xcellent, but are liable to split after having been boiled frequently. Figure shows how a leaden mallet becomes spoiled by use. avy wide-faced bronze mallet is efficient and dura- Many surgeons use an ordinary steel hammer.

FIG. 1170.—Gouge.

n emergency any block of wood or a potato masher serves every purpose is easily sterilized by boiling. Rawhide mallets are usually light and ot withstand boiling satisfactorily.

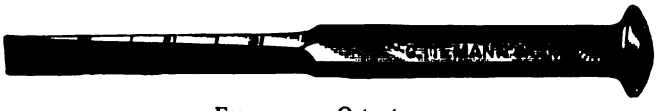


FIG. 1171.—Osteotome.

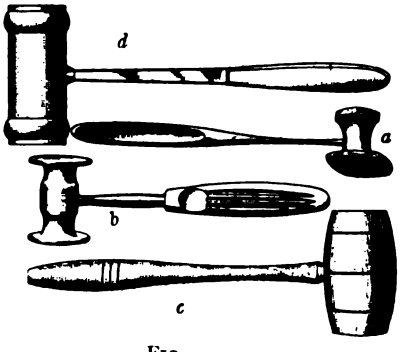


FIG. 1172.

d mallet, face mushroomed from use; *b*, large bronze mallet; *c*, wooden mallet; *d*, Mixter's mallet of vulcanized fibre.

METHODS OF USING CHISELS

In osteotomy the old saying "the more haste, the less speed" ho
One should work systematically. In cutting out a wedge-shaped pi
a bone one is tempted to insert the chisel and make it penetrate to
depth of the cut which must be made. If one does this, the chisel wi
be jammed and gripped in the bone, causing trouble and loss of tim
should content one's self by merely cutting through the external layer
bone until the whole wedge is outlined, and then step by step penetra
deeply. Macewen, who is a past master in the use of the chisel, seiz
down in the palm of the left hand, so low, in fact, that the ulnar side of t
is supported by the patient's body, the thumb of the left hand being e
up the chisel with its tip resting against the under surface of the expand

FIG. 1173.—Macewen's method of holding osteotome. (*Tubby.*)

of the handle (Fig. 1173). The object of this is to prevent any too sud
great onward movement of the instrument, *e.g.*, when passing from
to cancellous bone. Whenever a few taps of the mallet have caused
strument to penetrate a short distance into the bone it must be slight
drawn so as to avoid jamming. Slight pressure upward with the lef
generally suffices; often, however, a little lateral motion given the chisel
Backward and forward motion of the instrument is not permissible; such
is liable to break it.

In preparing for an osteotomy the part to be operated upon must r
sand-bag and should, if possible, be so placed that the chisel cuts aw
important soft parts and toward the surgeon. The surgeon can wo
accurately cutting toward than away from himself.

The size of the wound in the soft parts depends on the work to be d
the dexterity of the surgeon. The educated hand, using the chisel as
is independent of the assistance of the eye. It is safer for those who l
had large experience to make an external wound sufficiently large to all
eye supervising the work.

When section of a large and strong bone is contemplated, three
osteotome should be provided. The thickest-bladed instrument is u

hen this has penetrated the bone to such a depth that its thickness causes to become jammed, it is replaced by the next finer instrument which suffers o obstruction from the sides of the cut made by the previous osteotome.

3. **Saws.**—Saws are frequently used instead of chisels for dividing bone. he ordinary surgical saws, such as are used in amputations, are unsuitable for

FIG. 1174.—Adams' saw.

FIG. 1175.—Jones' saw. Note button on point.

FIG. 1176.—Finger saw.

FIG. 1177.—Gigli saw.

eotomy. Undoubtedly Adams' saw (Fig. 1174), or Jones' modification of it ig. 1175), is the best pattern. The ordinary "finger saw" is also useful ig. 1176).

Chain saws have been much used for the division of bone, but they are pensive, easily broken, difficult to handle and are now practically displaced the simpler and more efficient wire saw of Gigli (Fig. 1177).

first one used and remove the latter. The wide groove left by the passage of the coarser gives great delicacy and precision to the use of the more delicate instrument. With this finer instrument complete the section of the femur along the line described, to a point near the outer layer of cortical bone. It is wise not to divide the outer layer of bone with the osteotome.

(B) Partially withdraw the osteotome. Change the direction of its cutting-edge and make it cut through the whole cortical bone on the inner side of the femur (Fig. 1180).

(C) Once more change the direction of the osteotome and with it cut the bone from its anterior inner toward but not to its posterior external borders. Of course in many cases, *e.g.*, in children, the first line of bone section is all that is required, but in others where the bone is large the above systematic procedure will be found expeditious and *safe*. The osteotome ought not to be removed from contact with the bone until the bone section is completed, as its reintroduction through the small incision in the soft parts is a matter of much difficulty. All the procedures described can be carried out through a small wound.

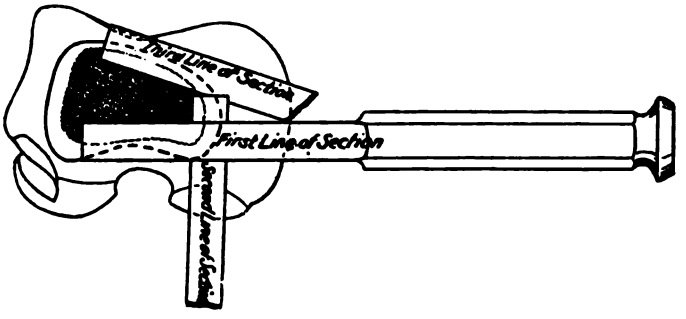


FIG. 1180.—Original lines of section of the femur in osteotomy.

Step 3.—Remove the osteotome. Cover the wound with an aseptic pad. With one hand grasping the femur at the site of operation and the other grasping the leg, complete the rectification of the deformity by breaking or bending the partially divided femur.

Step 4.—Apply dressings. Remove the elastic constrictor. Treat as a simple fracture of the femur. Both limbs are usually operated upon at the same sitting.

II. **Cuneiform Osteotomy.**—The operation as performed for angular anterior curvature of the tibia may be taken as typical. Render the limb bloodless. Apply an elastic constrictor (some surgeons omit this precaution as they fear increased subsequent oozing).

Step 1.—Make a longitudinal incision down to the bone over the most prominent part of the tibia. This cut need not be much longer than the width of the chisel, as the wound in the soft parts can easily be made to slide in various directions to expose different portions of the bone. Reflect the periosteum with the soft parts. Keep the wound open with retractors.

Step 2.—With an ordinary chise outline the base of a wedge by cutting [redacted] cortical bone. This base correspond to the apex of the angular

deformity (Fig. 1181) and should be *smaller* than that which it is belie be necessary. With the chisel cut through the cancellous bone and r wedge-shaped portion of bone. Do *not* cut through the whole thickne bone; the posterior undivided portion, corresponding to the apex of th is easily fractured by manual force. Straighten the limb. If sufficie has not been removed, it is easy to slice off more with the chisel u minimum amount which permits of correction has been removed. fibula interferes with the correction it must be bent or broken by man or divided with an osteotome.

FIG. 1181.—Cuneiform osteotomy.

Step 3.—If the wound tends to gape, intr few sutures. Apply aseptic dressings. Imm It is well to elevate the limb for twenty fo or longer. The subsequent treatment is the for simple fracture.

III. **Subcutaneous Osteotomy by Mean Saw.**—A good type of this operation is tha Adams for the intra-capsular division of the the femur in cases of anchylosis in bad positi

Step 1.—Introduce a long, narrow-blade (Fig. 1182) at a point one finger's breadth ab top of the trochanter major, and push it on encounters the neck of the femur, over w must be passed in a direction at right angle axis of the neck. The route taken by the practically one parallel to Poupart's ligament. the knife *in situ*.

Step 2.—Pass an Adams' or Jones' saw alongside of knife until the the saw are in contact with the femoral neck (Fig. 1183). Remove th With the saw divide the bone. While sawing one is liable to pull saw out of the cut in the bone and have much difficulty in reintrodu The hook or break on Jones' saw prevents such an accident. Before ob complete rectification it may be necessary to divide the tendons of the a longus, sartorius and perhaps the rectus muscles.

FIG. 1182.—Adams' knife.

Step 3.—Apply aseptic dressings. Immobilize the limb in a posi slight flexion and abduction.

Genu Valgum. Knock-knee.—There are three bony deformitie monly present in knock-knee.

(1) Difference in size of the condyles, *i.e.*, elongation of the inter

(2) Bending of the lower end of the diaphysis of the femur. Macewe this in 120 out of 166 affected bones. In some cases the same effect is o without true bending of the bone, by an elongation of the inner side of th which naturally pushes down the inner portion of the epiphysis.

(3) Bending of the upper end of the tibial diaphysis. The most important deformity in knock-knee is the bending of the lower end of the femur, but all the deformities mentioned have had operations devised for their correction.

Osteotomy for the correction of genu valgum.

(*A*) Macewen's, directed against the bending of the lower end of the femur (see p. 966).

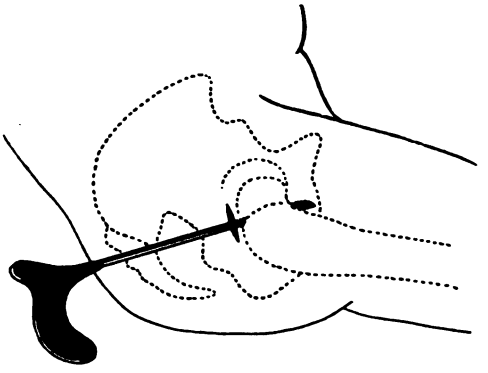


FIG. 1183.—Division of neck of femur.

(*B*) Supra-condyloid osteotomy as done in the New York Hospital for Ruptured and Crippled (Whitman, "Orthop. Surg.,' 421):

Place the *inner* surface of the semiflexed knee on a sand-bag. Grasp the femur above the condyles and pass a short osteotome about the size of a lead-pencil through all the soft structures down to the bone at a point 1½ inches above the external tuberosity. The cutting edge of the osteotome must be

FIG. 1184.

FIG. 1185.

FIG. 1186.

FIGS. 1184, 1185 AND 1186.—Macewen's linear supracondyloid osteotomy.

kept parallel to the long axis of the thigh until it comes in contact with the bone when it is to be turned transversely to the bone. Drive the osteotome through the cortical bone until so much is divided that the remainder is easily fractured. The rest of the treatment is the same as in Method A.

Inspection of Figs. 1184, 1185, 1186, shows that theoretically Macewen's operation is the better, but it must be admitted that a clean osteotomy gives good results whether performed from the inner or the outer side.

(*C*) **Ogston's operation: Osteo-arthrotomy.**—This, the first successful operation for knock-knee (1876), is directed against the real or supposed lengthening of the internal condyle.

Step 1.—Flex the knee as fully as possible. Introduce a narrow-bladed knife or elongated tenotome (Adams's knife) through the skin at a point 2 or 3 inches above the tip of the inner condyle. Push the knife downwards, forwards

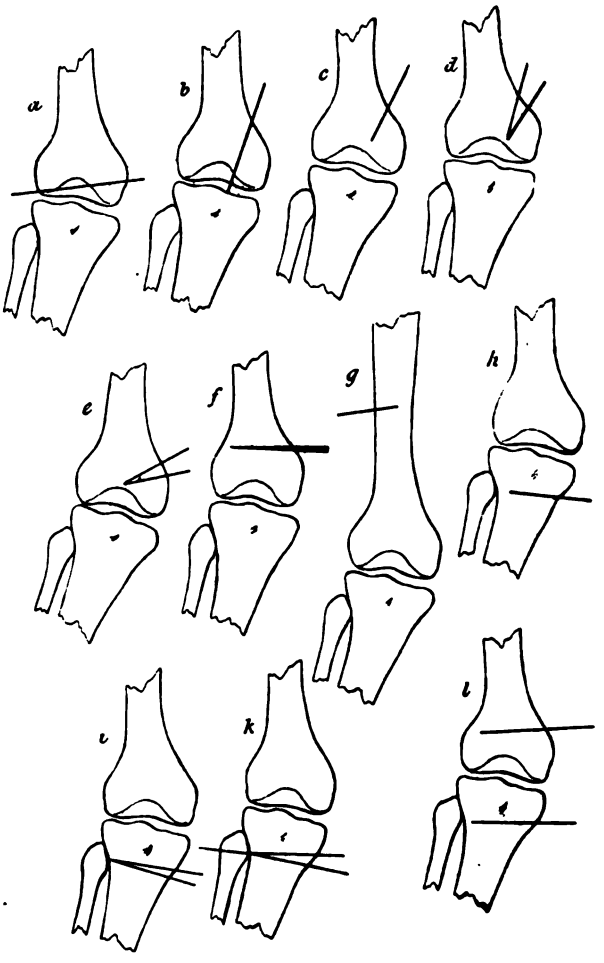


FIG. 1187.—(*Hoffa.*)
Annandale; *b*, Ogston; *c*, Reeves; *d*, Macewen's cuneiform osteotomy; *e*, Chiene; *f*, Macewen's supracondyloid; *g*, Reeves; *h*, Billroth; *i*, Mayer; *k*, Schede; *l*, Barwell.

and outwards until the point is felt in the intercondyloid space. Turn the edge of the knife towards the bone and in withdrawing it cut the soft structures to the bone.

Step 2.—Introduce an Adams's saw through the knife wound and divide the internal condyle from above downwards for three-fourths of its thickness. Complete the fracture by straightening the limb, when the loosened condyle will slip upward (Fig. 1187).

Step 3.—Immobilize and treat as a fracture.

(*D*) Reeves' operation is similar to Ogston's but in it the bone section is made with a chisel down to but not through the articular cartilage, thus avoiding any direct opening of the joint. Fowler and Pilcher long ago showed that this operation has nothing to recommend it.

(*E*) Chiene's operation differs from Ogston's in that he removes with the chisel a wedge of bone from the base of the condyle. The operation is unnecessarily difficult.

(*F*) **Section of Tibia.**—*Step* 1.—On the inner surface of the tibia, midway between its anterior and posterior borders make a longitudinal incision down to the bone. The cut should be only large enough to easily admit the osteotome.

Step 2.—Introduce the osteotome and turn its cutting edge transversely to the bone. Divide the tibia from within outwards, "commencing from the posterior border and raising the osteotome gradually up until it comes into contact with the anterior surface of the lower portion of the tubercle, which is by far the most dense portion" (Macewen). Next divide the dense bone on the outer side of the tibia from before backwards. Complete the fracture by manual force. It is unnecessary to divide the fibula.

Osteoclasis in Genu Valgum

(A) **Manual.**—Administer a general anesthetic. Place the patient on his back. Let an assistant firmly grasp and steady the upper portion of the thigh. With one hand grasp the femur immediately above the deformity, with the other hand grasp the leg. Fully extend the knee and endeavor forcibly to bring the limb into a straight position. When correction is obtained it is usually due to the production of one or several of the following lesions: Fracture, green stick or complete, of the lower end of the femur; separation of the femoral or tibial epiphysis or of both; fracture of the internal condyle (as produced in Ogston's operation); rupture of the external lateral ligament.

(B) **Instrumental Osteoclasis.**—This operation as applied to knock-knee is carried out in much the same manner as in the case of bow-leg and hence requires no description here.

Indications for Operation in Knock-knee.—Mechanical treatment by massage and apparatus often gives good results in moderate degrees of deformity in patients *under four years of age.* After the fourth year improvement cannot be expected from other than operative treatment, hence operation is positively indicated in every case of knock-knee where the patient is over four years of age, where *disability* is present, *provided that* the general health of the patient is fairly good. The operation, being practically without danger, is permissible for æsthetic reasons in patients whose health is good.

Choice of Operation.—Osteoclasis.—Theoretically, the danger of epiphyseal separation causing subsequent want of bone development is a serious objection to osteoclasis, but experience seems to show that these dangers have been much exaggerated. Osteoclasis is suitable only in the very young where the bones are still soft. On the whole, however, osteoclasis whether manual or instrumental is very inferior to osteotomy in that it produces more injury than, and lacks the definiteness of the latter operation.

Osteotomy.—Only when the tibial curvature is much greater tha femoral does the former require division. This is a rarity. In very ra exaggerated cases osteotomy both of the tibia and of the femur may b formed, although in these circumstances femoral osteotomy plus divisi the biceps tendon has given as good or better results than double osteo All other osteotomies for knock-knee have been practically superseded b Macewen supra-condyloid operation or some modification of it.

CHAPTER LXXIV

BOW-LEG. GENU VARUM

Typical genu varum is the result of external bowing of the femur a the leg bones. The maximum curve is generally near the knee. Bow-leg be the result of lateral bending of the leg bones alone, the femur being unal An anterior curvature of the tibia gives another form of bow-leg. Oper correction is demanded in all severe cases. Before the age of four or five mild deformities may be corrected by mechanical appliances; after that operation affords the only prospect of cure.

Methods of Operating.—(I) **Linear Osteotomy.**—Note which bon bones are most seriously affected. Usually in typical genu varum both femur and tibia are badly curved. Note which part of the individual is most bent; it is this part which must be divided.

(a) If osteotomy of the middle third of the femur is indicated, make a ve incision through the soft parts down to the bo the outer or antero-external side and proceed supra-condylar osteotomy, in this case, however ting the bone from without inwards. (b) If the is most affected, incise vertically the soft parts to the bone over the inner surface of the bone a point of greatest curvature. Introduce the c tome and then turn it transversely to the bon divide the cortical bone of the inner and outer of the tibia, and especially that of the anterior ma Be careful not to injure the anterior tibial vessel nerves which lie close to the outer surface of the Fracture the posterior layer of cortical bone by ma force. Forcibly fracture or bend the fibula. I is impossible, palpate the fibula and make a incision down to it through the soft structures o outer side of the leg. Introduce a very narrow c tome and divide the bone. (c) If femur and tibia are both markedly cu operate on both at the same sitting.

FIG. 1188.—Oblique osteotomy.

Note.—The object of the surgeon is to correct the deformity. If div of one bone is not sufficient, then divide the other as well; if this is insuffi repeat the operation at whatever places it may be demanded. Macewen performed ten osteotomies on the same patient at the same sitting and obta a good result.

II. **Cuneiform osteotomy** is particularly suitable in cases of anterior curvature of the tibia (see p. 967).

III. **Oblique Osteotomy** (Ollier).—In some cases, especially of anterior curvature of the tibia where there is much shortening, oblique division of the bone (Fig. 1188) permits elongation. To attain this elongation it may be necessary to lengthen the tendo Achillis by means of any one of the well-known methods.

FIG. 1189.—Grattan's osteoclast.

FIG. 1190.—Collin's osteoclast.

IV. **Osteoclasis.**

(A) **Manual.**—Grasp the bone affected above and below the point of the greatest curvature and bend it straight or produce a fracture. In the very young a green-stick fracture is a desirable lesion to produce. It is often necessary to support the point of greatest convexity on a fulcrum (*e.g.*, a padded wedge of wood) before sufficient force can be applied. It may be necessary to produce multiple fractures.

(B) **Instrumental.**—The necessary fracture or bending may be more precisely and definitely produced by means of an osteoclast. Probably Grattan's

osteoclast (Fig. 1189) is the best. Place the limb in the instrument in fashion that the movable arm (a) is applied to the point of greatest co while the opposite or concave side of the limb is supported by the two fixed arms of the osteoclast. By means of the screw (x) make a move (a) press against and fracture the limb. Fig. 1190 shows Collin's os

By whichever means the limb is straightened, it must be fixed in go tion by plaster of Paris or apparatus and treated as an ordinary fractu the treatment of bow-legs osteotomy and osteoclasis seem to give about good results.

CHAPTER LXXV

OPERATIONS ON THE PELVIC BONES

Operations on the bones of the pelvis are indicated in acute osteom tuberculosis; sarcoma, etc.

1. **Acute Osteomyelitis and Periostitis.**—The method and time of tion must vary according to circumstances. "In the severest cases wi fever, great local pain and swelling an incision should at once be made point of greatest tenderness or swelling" (Tillmanns), all sequestra and d bone removed and drainage provided. When the disease is on the ou of the ilium the above advice is easily carried out; when, however, the is principally on the inner side of the bone it is necessary to trephine o to excise a larger or smaller amount of the ilium in order to provide drainage. To do this the author has found it necessary to operate times, in an individual case. When there is extensive disease, extens posure of the bone is necessary.

When the inflammation and swelling are diffuse and fever is high m tematized resection of bone is necessary and the whole affected bone sh early removed. When the local and general symptoms of the disease ar non-operative treatment should be adopted until recovery takes place incidence of abscess or threatening symptoms indicate operation.

2. Chronic pyogenic osteomyelitis with fistula calls for operation.

3. Tuberculous osteomyelitis is usually situated near and commonly in one of the joints so that the treatment is generally directed primarily the arthritis (hip-joint disease; sacro-iliac disease).

4. Neoplasms. All malignant neoplasms demand excision provided is a moderate chance of success. All non-malignant neoplasms threa life from pressure, etc., similarly demand removal. All other neo demand removal provided that the operation is not one of much gravity usual rule of very wide excision prevails in operations for malignant t when removing such neoplasms as osteomata and chondromata a portion pelvis itself ought to be removed to make sure that the base of the neop not left.

Every extensive operation on the ilium requires free exposure of the This may be obtained in various but similar ways.

A. **Sprengel's Method.**—Make an incision from the anterior s spine of the ilium, downwards along the anterior border of the tensor

femoris and divide the deep fascia (Fig. 1191). From the upper end of the incision cut backwards along the iliac crest dividing the fascia and the origin of the gluteus medius and minimus.

Through the above incision separate the muscles and periosteum from the pelvis and retract them downwards and backwards. This gives good exposure of the ilium and of part of the acetabulum. Though this incision Kocher removed an exostosis from the acetabulum. When the active operation is finished, the flap is easily replaced.

B. **Larghi's Method** (see p. 987).

C. **Kocher's Method.**—Kocher excised one-half of the pelvis for sarcoma as follows:

Step 1.—Make an incision from the sacro-iliac synchondrosis forwards along the iliac crest and Poupart's ligament.

Step 2.—Divide the abdominal muscles attached to the iliac crest and Poupart's ligament; separate the transversalis fascia and peritoneum from the tumor until the iliac vessels are exposed. Retract the iliac vessels and the anterior crural nerve inwards.

Step 3.—Isolate and divide the muscles passing under Poupart's ligament external to the great vessels. Divide the rectus femoris, sartorius, tensor vaginæ femoris. Separate the

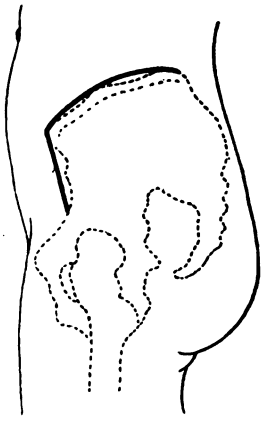


FIG. 1191.—Sprengel's incision.

FIG. 1192.—Result of excision of pelvis. (*Kulenkamff.*)

gluteus medius and minimus bluntly from the ilium until the sacro-iliac articulation is reached. Anteriorly divide the ilio-psoas muscle and the capsule of the hip-joint.

Step 4.—Divide the horizontal ramus of the pubis and the ascending ramus of the ischium.

[illegible]ate the sacro-iliac articulation and dislocate the bone downwards.

Step 5.—Separate the rest of the pelvic attachments by blunt and sharp section. The flexors arising from the tuber ischii and the sacro-sciatic ligam require division. Excise the head of the femur. Remove the mobilized por of pelvis.

Step 6.—Suture the abdominal muscles to the glutei. Close the woun deep and superficial sutures after providing freely for drainage.

Kocher remarks that the bleeding is only moderate as no large vessels injured but that it might be well to ligate the internal iliac vessels before tracting them in Step 2.

D. **Kulenkamff's Method.**—*Step* 1.—Secure temporary hemostasis Momberg's method. Make an incision along the crest of the ilium and I part's ligament. Separate the iliacus muscle (if it is not involved in the dise and retract it along with the iliac vessels inwards.

Step 2.—Perpendicularly to the first incision make a cut reaching down to trochanter major. Open the hip-joint and decapitate the femur.

The rest of the operation is practically the same as Kocher's. Figure 1 shows the result obtained by Kulenkamff. (Beiträge z. klin. Chir., lxviii, 7

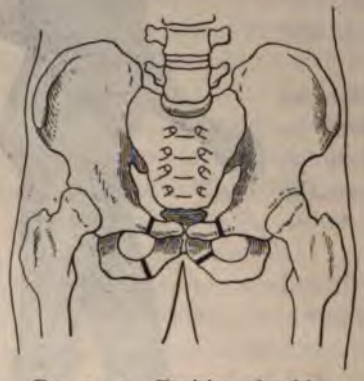


FIG. 1193.—Excision of pubis.

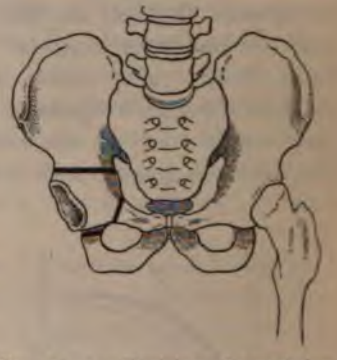


FIG. 1194.—Excision of acetabulum.

Excision of Symphysis Pubis.—Tuberculous osteomyelitis affecting pubic bones and the symphysis calls for early operation. The disease may exposed by an incision directly over it; all affected bone cut away with chisel mallet and all abscesses opened and curetted. If no distinct and separa sequestrum is present v. Bünger recommends that a transverse incision be m immediately above the pubis, the soft parts separated and the bone divi subperiosteally beyond the disease (Fig. 1193).

The results of the operative treatment of pubic tuberculosis are good.

Excision of the Acetabulum.—Schmidt's Method.—*Step* 1.—Open hip joint through Langenbeck's incision (p. 982). Dislocate the head of femur (if necessary excising it).

Step 2.—Adduct and rotate the limb outwards. From the middle of wound make a cut at right angles forwards towards the anterior inferior i spine. This cut penetrates to the bone. By blunt dissection separate the p osteum and overlying soft parts from the ilium above the acetabulum from anterior inferior spine to the sciatic notch.

Step 3.—With chisel and mallet divide the ilium transversely above the acetabulum (Fig. 1194). Be careful not to injure the pelvic contents.

Step 4.—Divide the horizontal ramus of the pubis with a Gigli wire saw.

Step 5.—With a periosteal elevator separate the soft parts from the ischium below the acetabulum. Divide the ischium with a Gigli saw or a chisel (Fig. 1194).

Step 6.—Seize the acetabulum with bone forceps and remove it, dividing any obstructing connections with scissors.

Step 7.—Provide for drainage. Close the wound. Dress. Put up in a position of marked abduction.

CHAPTER LXXVI

SACRO-ILIAC DISEASE

Jacobson and Rowlands ("Operations of Surg.," ii, 874) write regarding tuberculosis of this joint:

"It has been shown that the prognosis in this disease, usually looked upon as so grave, is much better if the same radical methods of treatment, which have proved so satisfactory in other joints, are applied to the sacro-iliac synchondrosis."

Mr. Collier first drew attention to the above fact with a case successfully treated by trephining (Lancet, 1889, vol. ii, p. 787), and Mr. Makins and Mr. Golding Bird followed, each surgeon publishing three successful cases ("Clin. Soc. Trans.," vol. xxvi, p. 127, and vol. xxviii, p. 186).

The following points are taken from these papers:

Operation.—The joint is exposed by a crucial incision (Makins), or by a flap (Collier, Golding Bird). In the words of the last-named surgeon, "a semicircular flap of skin and subcutaneous tissue over the iliac area of the joint, and having its convexity corresponding to the posterior edge of the ilium, is dissected upwards and forwards, and the underlying glutæi are detached. The bone being thus freely exposed, a large trephine is applied at the root of the posterior inferior iliac spine, and in a line drawn from the top of that spine to the junction of the anterior with the middle third of the iliac crest. . . . . The ilium at the seat of operation is very thick, but the disc of bone removed should reach quite down to the joint." The trephine-opening is then sufficiently enlarged, the articular surfaces cut away with a gouge or forceps sufficiently to enable the surgeon to explore the pelvis surface of the joint, and to liberate any pus lying on this aspect. The sharp spoon, or Barker's flushing gouge, is then thoroughly used, all fragments of bone, granulation tissue, or loosened cartilage removed, and any sinuses present laid open. Sterlized iodoform having been next applied, the soft parts are lightly drawn together with a few sutures. A long outside, or a Thomas's hip-splint, should be used at first, but subsequently all that is needed is a well-fitting pelvic belt, as advised by Mr. Hilton."

Bardenheuer and Picqué ("Journ. de Chir.," Sept., 1910) have each described more systematic methods of excising the sacro-iliac joint. Picqué's method is the one described here.

Step 1.—Make a curved incision penetrating to the bone along the posterior third of the iliac crest and continued down the border of the sacrum to the level of the third posterior-external tubercle. With periosteal elevator reflect the periosteum and superjacent soft parts from the outer surface of the posterior portion of the ilium.

Step 2.—The sacro-iliac joint is so situated that to reach it a portion of the ilium must be removed (Fig. 1195). The excision of the segment of bone may be complete or partial.

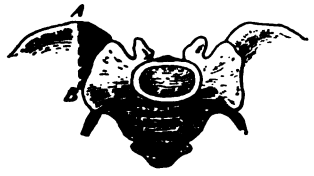


FIG. 1195.—Exposure of sacro-iliac joint.

(a) *Complete.*—With an osteotome divide the iliac bone vertically from the crest down to the outer and upper corner of the great sciatic notch (Fig. 1196).

(b) *Partial.*—Make the vertical incision shorter and supplement it by a transverse one (Fig. 1196) in such a fashion as to leave the sciatic notch intact.

Having divided the ilium pry up the fragment of bone with an elevator, divide its ligamentous attachments and remove it. This removes the iliac portion of the sacro-iliac joint and freely exposes the articular and adjacent portions of the sacrum.

FIG. 1196.—Exposure of sacro-iliac joint. (*Picqué.*)

Step 3.—Systematically with scoop, rongeur forceps and chisel remove all disease from the sacrum. In doing this, so shave away bone that no irregular pits or tunnels are left which would interfere with proper drainage. If the disease extends to the sacral foramina, working in the above systematic fashion permits the exposure and isolation of the nerve trunks which would be exposed to much injury if the curette was used blindly. The amount of bone removed must vary with the extent of the disease. In one case, Picqué writes, "the wound will have a bony floor formed by the anterior portion of the sacrum united to the ilium by the anterior sacro-iliac [illegible]

case the wound will penetrate the pelvis exposing the sacral nerve trunks, the iliac vessels and the ureter. Thus the resection of the sacrum like that of the ilium may be partial or complete." When extensive resection of the sacrum is necessary it will usually be found that nature has already protected the pelvic organs by a deposit of strong fibrous tissue.

Step 6.—Close part of the wound with sutures and pack the rest with gauze. Picqué writes, "however thorough the resection has been, points of caries will always appear on the surface of the spongy bone, interfering with cicatrization, there will be exuberant granulations from the superficial soft parts and the dressings should be made curette in hand." The duration of post-operative treatment varies much (six weeks to three months—Bardenheuer; three to eight months—Picqué). The author has had no experience with the Bardenheuer-Picqué operation but it strikes him that the use of Mosetig's iodoform wax plug might facilitate healing.

Results.—Bardenheuer reports a series of sixteen cases with 69 per cent. recoveries and a second series of four cases with 100 per cent. recoveries, Picqué reports six cases with 66 per cent. recoveries.

CHAPTER LXXVII

HIP

Snapping hip; Hanche a ressort; Schnellende Hufte; Schnappende Hufte, are names given to the same affection. On very slight motion of the hip the patient can procure a palpable and audible snapping which simulates a dislocation in a very persuasive manner. The trouble is due to a prominent sausage-shaped mass of tissue slipping forwards or backwards over the upper part of the trochanter major. In one case observed by the author fixation of this mass by the operator's fingers prevented snapping. The mass consists of part of the gluteus maximus. (Heully, "Rev. de Chir.," May, June, July, 1911; Bayer, "Archiv für klin. Chir.," lxxxii, 266; Voelcker, "Beiträge z. klin. Chir.," lxxii, 619; The author, "Annals Surg.," lviii, 59; Manon, La Pr. Med., Oct., 29, 1919, A. Mariau, La Pr. Med. Dec. 27, 1919.)

In one of the author's cases there was much disability and a good result was obtained by the following operation:

From about ½ inch above the great trochanter make a cut downwards along the middle of the bone for about 3 inches. Divide the fascia lata corresponding to the skin wound. Incise the periosteum longitudinally on the lower part of the trochanter and elevate a small periosteal flap. Suture the posterior edge of the wound in the fascia lata to the periosteal flap and to the insertion of the vastus externus. Suture the anterior edge of the fascial wound so as to make it overlap the line of fixation of the posterior edge. Close the skin wound. Dress. Immobilize the hip for several weeks.

In one case Voelcker exposed the fascia lata over the great trochanter and divided it longitudinally behind the palpably thickened ilio-tibial band. Underneath the fascia the gluteus maximus appeared and contained a strong

band of tendon which was inserted into the ilio-tibial band. Division band without suture of the fascia led to cure.

Manon made an incision along the axis of the trochanter major and nized that the aponeurosis going from the gluteus maximus to the fas was the culprit. Division of this aponeurosis at right angles to its fib complete relief.

A. Mariau finds that transverse section of the posterior part of the il band is sufficient for cure. If his views are correct and they proba then all more complicated operations may be discarded.

Iodoform Injection.—Krause describes the introduction of the tro cannula as follows: The trocar ought to be from 2¾ to 3½ inches in The patient lies flat on his back. Flexion of the thigh should be av possible, while abduction and external rotation *must* be avoided. Th should be in a position of adduction and slight internal rotation. Intro trocar at right angles to the axis of the femur, at a point immediately al tip of the trochanter major and midway between its anterior and p borders. Push the trocar slowly onward until its point strikes bone (t of the femur or the neck near the head). Adduct the limb strongly, kee point of the trocar constantly in touch with the femoral head, push the ment cautiously upwards and inwards until bony obstruction is ag countered. The point of the instrument is now lying between the hea femur and the rim of the acetabulum. Withdraw the stylette and p cannula still further into the joint. The method of injecting, the n to be used and the after-treatment are the same as have been describe chapter on operation upon the knee.

Vaseline Injections.—Rovsing ("Annals Surgery," Dec., 1909) adv injection of sterile vaseline into joints affected with traumatic dry ar If any turbid fluid escapes through the cannula no injection of vaseline be made, a little clear synovial fluid escaping does not contraindicate in In the adult about 20 c.c. of vaseline is the correct quanity to throw i hip-joint.

A trocar and cannula is the proper instrument to employ—a cannul cutting-edge but no trocar is too dangerous.

Rovsing has had a special apparatus made: (Fig. 1197) "a tube o rubber 10 cm. long, which at one end is provided with a brass ring whi be screwed on to the ordinary vaseline tubes, while the other end can be screwed into the cannula and partly into a close fitting cover, which cannula and during the boiling can be closed with a little cover; provide this cover the rubber tube is screwed on to the vaseline tube and is now together with this for fifteen minutes before the injection. Then the punctured, the poincon is removed, and the presence of synovia in th ascertained. In such a case catch the synovia in sterile glass tubes for ex tion. If it is found to be turbid and fluffy the injection of the vas abandoned, but if none or only an inferior mass of clear synovia is fou vaseline tube is taken direct from the cooking vessel and connected w cannula by the connection tube, which after the cover has been remov be screwed straight on to the cannula. The vaseline is now driven t

the tube and cannula in this way; the vaseline tube is rolled up from the bottom by the aid of a tiny little handle (Fig. 1198). By this means every possibility of infection of the vaseline passing from the tube to the joint is precluded, and the method is in every respect practical."

Rovsing when injecting insures against missing the hip-joint by exposing the capsule through a small incision just above the trochanter.

FIG. 1197.—(*Rovsing, Annals of Surgery.*)

FIG. 1198.—(*Rovsing, Annals of Surgery.*)

Arthrotomy.—There are several routes through which the hip-joint may be opened.

I. **Anterior Arthrotomy.—Method A.**—*Step* 1.—From a point about 1 inch below and a finger's breadth internal to the anterior superior iliac spine make an incision 3 or 4 inches in length downwards along the inner border of the sartorius (Fig. 1199). Expose the inner border of that muscle and retract it

FIG. 1199.—Incision of anterior arthrotomy of hip.

outwards; this exposes the tendon of the rectus femoris which must be retracted outwards, exposing the ilio-psoas muscle. Retract the psoas *inwards*. The joint capsule is now exposed.

Step 2.—Flex and abduct the thigh, rotating it outwards. This permits more free access. Incise the capsule. Explore the joint. If drainage is required, provide such and partly close the wound.

Method B.—*Step* 1.—From a point about ½ inch below and extern the anterior superior iliac spine make a 3- or 4-inch incision downwards slightly inwards. The upper portion of the cut runs along the outer b of the sartorius, lower down where the sartorius and tensor vaginæ fe separate, the cut takes a course midway between these muscles. Retrac sartorius and rectus femoris muscles inwards. The joint capsule is now exp

Step 2.—Same as in Method A.

If on account of suppuration it seems desirable to provide further dra through a counter-opening, Labey advises the following procedure: Ab the thigh so as to make the adductor muscles prominent. Locate the addu longus. Make a 4-inch incision along the outer border of this muscle, b ning about one finger's breath from the fold of the groin and a little ext to the root of the scrotum. Divide the skin and subcutaneous tissue. Re the long saphenous vein outwards; ligate and divide any of its branches w cross the wound. Divide the deep fascia along the outer border of the addu longus. Push the finger between the adductor longus and the pectineus w

FIG. 1200.—Drainage of hip. (*Labey.*)

FIG. 1201.—(*Esmarch and Kowalzig.*)

FIG. 1202.—(*Labey.*)

FIGS. 1201 AND 1202.—Langenbeck's arthrotomy.

lies immediately external to it. The thigh being now flexed as well as abduct hook the finger under the pectineus. Introduce a closed forceps through arthrotomy wound, make the forceps traverse the joint inwards and downwa so as to make the inner and lower part of the capsule prominent and to c against the finger pushed into the secondary wound (Fig. 1200). Guided by finger, make an incision through the capsule on to the forceps. With the forc pull a large drainage-tube through from one wound to the other.

II. **Posterior Arthrotomy.—Method A, Langenbeck's Method.**—Place patient on his healthy side (latero-ventral position). Flex the thigh t position midway between extension and flexion at a right angle to the body (4

Step 1.—Beginning at a point about two fingers' breadth below the of the trochanter, make an incision along the mid-line of the trochante the long axis of the femur, upwards for about 4 to 4½ inches towa the posterior superior iliac spine (Fig. 1201). Divide the skin and s cutaneous fat so as to expose the gluteus maximus and the trocha which is covered by the strong flat tendon of the gluteus maximus.

Step 2.—Divide the tendon on the trochanter in the line of wound and continue this division upwards so as to penetrate the gluteus maximus by separating its fibres. Retract the edges of the muscular wound exposing and then dividing the layer of fat covering the deeper structures. Expose the pyriformis (posterior and inferior) and the gluteus medius (anterior and superior). Note and penetrate the groove between these two muscles. Retract the edges of this deep wound so as to expose the posterior surface of the capsule.

Step 3.—Incise the capsule (Fig. 1202).

Method B.—Kocher's Curved Incision.—This method is described in the chapter on arthrectomy.

Arthrectomy. Anterior Incision.—Several methods have been devised for approaching the joint by the anterior route only Barker's plan will be described. This operation is enthusiastically advocated by A. E. Barker.

Step 1.—See Anterior Arthrotomy, Method B.

Step 2.—Open the joint capsule by an incision parallel to the neck of the femur. Explore. Do *not* dislocate the head of the bone through the incision. Divide the neck of the femur with a fine saw (Adams's) or an osteotome. Remove the head of the bone. Removal of the normal femoral head is exceedingly difficult, but when tuberculous disease is so advanced that excision is necessary, the tissues are so altered and softened that extraction of the head is usually easy; to this rule there are some striking exceptions, when the head of the femur may require to be chiseled from the cotyloid cavity.

Step 3.—With the irrigating curette scrape away all soft broken down tissues. With long forceps and scissors dissect away all evidently diseased synovialis, etc. Examine the acetabulum and its surroundings and if found diseased, remove the foci with the curette, chisel, or gouge. Thoroughly douche the cavity with warm water tinged to a dark sherry color with tincture of iodine.

Step 4.—(*a*) No evidence of secondary (pyogenic) infection is present. Fill the wound with iodoform-glycerine or iodoform and formalin in glycerine. Close the wound without drainage.

(*b*) Sinuses are present or there is evident pyogenic infection. Provide for free drainage. Partly close the wound.

After-treatment.—Barker writes as follows:

"No splint is required immediately after the operation, the limb lying in good position, as a rule, if left to itself, no muscles having been divided. If there be any tendency to displacement a weight-extension will be the most suitable means of correcting it in the first instance. As the wound lies in front and is small, there is no difficulty in dressing it without moving the patient in the least, hence another reason for discarding splints at first. But when the wound is in a fair way to heal, the author is in the habit of putting the patient upon a double Thomas' splint, in which he can be removed from bed and be carried out for change of air without the least disturbance of the limb or of the dressing on the wound."

External or Langenbeck's Incision.—König's Method.—Place the patient on his sound side with the [illegible]ting-table so arranged that a good light falls on the hip. Three assist[illegible]ecessary. One stands opposite the surgeon.

one at the patient's back, and the third where he can manipulate the patient's l
The surgeon stands behind the hip. The thigh is in a position of semiflexio

Step 1.—Make a five inch incision over the middle of the trochanter n
in line with the long axis of the femur. Rather more than half of this inc
lies above the trochanter, between it and the posterior superior spine o
ilium (Langenbeck's incision, Fig. 1201). The knife is made to penetra
the bone in the first cut.

Step 2.—With long-bladed retractors separate the edges of the wound
pose the capsule and divide it. Divide the periosteum of the trochanter ir
line of the wound. Do *not* separate the trochanteric muscular insertions.

Step 3.—With a broad chisel *partially* cut off a shell of bone from the ant
and from the posterior margins of the trochanter. Complete the sep
tion of the shells of bone by blunt force, leaving them loosely attached to
shaft of the femur, the periosteum and soft structures acting as a hinge (

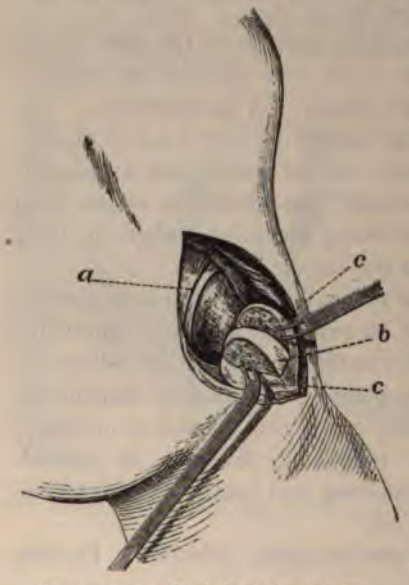


FIG. 1203.—König's arthrectomy.

1203, c, c). The separated portion
bone bear the insertions of the troch
teric muscles. The remaining portio
trochanter (b) must be removed flush
the femoral neck by means of the chis
bone forceps.

Step 4.—With retractors expose
femoral neck. Choose the point at wh
the neck is to be divided. With a p
osteal elevator bare the bone of the n
at the line of section. Divide the b
For this purpose use a finger saw,
better, the Gigli wire saw.

Step 5.—Removal of the femoral he
König writes as follows: "The remo
of the head is often difficult. Sometir
it has sunk into the cotyloid cavity wh
has been widened by disease and wh
inequalities of surface have hooked the
selves on to similar inequalities of
femoral head; sometimes it is so changed in form that it has become firm
fixed in an excavation of the acetabulum; occasionally its surface is partially
entirely united to the bone of the acetabulum. In other cases, especia
when acute osteomyelitis has been present, the epiphysis is separated and
head itself is anchylosed to the acetabulum.

FIG. 1204.—König's lever.

"In simple cases when room is made by pulling the limb downwards o
can remove the head with a periosteal elevator. In difficult cases a specia
strong, spoon-faced lever is required." (The author has had one made
the following dimensions, $14 \times \frac{3}{4} \times \frac{1}{4}$ inches (Fig. 1204). It reminds o
of a burglar's "jimmy," but is thoroughly efficient.)

"In unusally difficult cases one may chisel away a portion of the posterior superior rim of the acetabulum (a, Fig. 1203). This would be done in any event after the removal of the head."

Examine the trochanter and the remnant of the neck. If disease is present in these structures attack it with chisel and sharp spoon.

Step 6.—Examine the cotyloid cavity both by touch and sight. Remove sufficient of the posterior superior cotyloid rim to permit of free inspection of the cavity. If disease exists in the pelvic bones remove it *thoroughly* with chisel and spoon. In cases where the disease has invaded the pelvis and caused iliac abscess, the latter must be independently opened anteriorly above Poupart's ligament, its contents evacuated, its cavity cleaned, filled with iodoform-formalin glycerine and sutured.

Step 7.—**Excision of the Synovialis.**—Separate the synovialis from the rim of the acetabulum and from its inferior insertions, and dissect it out. Long stout dissecting forceps and scissors curved on the flat are convenient for this purpose. Changes in the position of the limb assist in giving free exposure. All the synovialis may be excised as above, except sometimes a pouch which runs down to the lesser trochanter and must be thoroughly curetted. The sharp spoon so often recommended for the removal of the synovialis is practically useless for the purpose.

Step 8.—Irrigate the wound with hot water. The addition to the water of sufficient tincture of iodine to make it a sherry color is valuable. Dry the wound with sterile gauze. Introduce a cannula or tube into the wound. Close the wound with deep and superficial sutures. Place one or more sutures (not tied) in such position that when the tube is removed they may be tied and effectually close the wound. Through the tube fill the wound cavity with iodoform-glycerine or iodoform-formalin-glycerine or Beck's bismuth vaseline. Remove the tube. Fasten the last sutures. Apply ample dressings.

James E. Moore recommends filling the wound cavity with Mosetig's bone plug. Mosetig himself originally only used this plug to fill cavities actually cut in the bone itself. His plan in articular caries was to cut (not scrape) away the focus, thoroughly dry the bone cavity left, fill the cavity with the iodoform wax, cover the plug with rubber tissue and gauze until the rest of the operation was completed, then he removed the rubber tissue and gauze and closed the wound after introducing short drainage-tubes. Moore in one case could not obtain sufficiently perfect hemostasis to permit the use of the "bone plug," hence he packed the wound with gauze for some days and introduced the plug secondarily with good results.

If secondary infection is a feature of the case and especially if sinuses exist, then the above treatment is improper; the sinuses must be cleaned by the sharp spoon, rubbing with gauze or by dissection. Filling the cavity and sinuses with Beck's bismuth paste seems to be efficacious, also the Carrel-Dakin treatment.

After-treatment.—Put the patient in bed. Apply extension by means of weight and pulley in a position of slight abduction. Keep up for from six to eight weeks or longer. Use nocturnal extension for a period of one or two years.

Within three weeks, if all goes well, begin gentle passive motion. After

the wound is satisfactorily healed massage combined with passive movement is indicated, and active movements may be begun. After the lapse of eight weeks the patient may be encouraged to walk with crutches. Huntington believes that in most cases of hip-joint disease, whether tuberculous or of acute infective origin, the primary focus is situated in the neck or the head of the femur. Guided by X-ray findings, he therefore trephines on the outer surface of the trochanter major near its base and through the trephine opening tunnels the neck of the femur until he reaches the disease (Fig. 1205). If sufficient disease to account for the symptoms is found before the epiphyseal cartilage is reached, do not penetrate that structure; if sufficient disease is not

FIG. 1205.—Tuberculosis of the hip. (*Huntington.*)

found in the neck, then the epiphyseal cartilage must be penetrated and the head entered. The time when this operation may promise most is the time when non-operative treatment is usually considered indicated, viz., early. The treatment is the same as was advocated by Macnamara (Huntington, "Surg., Gyn., and Obstet.," ii, p. 406).

Angular Incision. Kocher's Operation.—This incision may be used for arthrotomy as well as for arthrectomy. Place the patient on his sound side in the latero-ventral posture. Slightly flex the hip. Let an assistant grasp the leg so as to change the position of the thigh according to directions.

Step 1.—Beginning at the posterior margin of the base of the trochanter major, make a cut upwards to the posterior angle of the summit of the trochanter (Fig. 1206); at this point change the direction of the incision and cut upwards and backwards towards the posterior superior iliac spine, *i.e.*, cut

parallel to the fibres of the gluteus maximums and expose that muscle. Split the tendon of the gluteus maximus in the direction of its fibres, and enlarge the deep wound upwards and backwards by splitting the muscle itself in a space between its fibres (Fig. 1207).

Retract the edges of the deep wound, exposing the gluteus medius at its insertion into the trochanter.

Step 2.—Rotate the hip slightly inwards so as to make prominent the posterior angle of the summit of the trochanter. Find the groove between the gluteus medius and minimus above and the pyriformis below. Beginning at this point, separate with elevator or knife the insertions of the gluteus medius and minimus along with the corresponding periosteum from the trochanter until the intertrochanteric line is reached anteriorly. At this point separate the insertion of the ilio-femoral ligament. While doing this flex the thigh and rotate it outwards.

FIG. 1206.—Kocher's incision.

Step 3.—Divide the articular capsule along the lower edge of the pyriformis tendon; flex the thigh and rotate it inwards so as to gain access to and divide the insertion of the pyriformis. With elevator or chisel (removing a thin shell of bone if desired) separate the insertions of the obturators and gemelli.

The rest of the operation requires no special description.

Larghi's High Curved Incision.—A. Von Bergmann ("Archiv für klin. Chir.," lxix, 592) strongly recommends the above incision in cases where there is considerable involvement of the pelvic bones. The cut skirts the iliac crest and permits reflection downwards of the gluteal muscle. The operation was originally devised for excision of the ilium, but it has been used in tuberculous coxitis and especially in dislocation of the hip (*q. v.*).

Ollier's Snuff-box Method.—Place the patient on his sound side. Flex the thigh to an angle of 45° and adduct so as to make the trochanter prominent.

Step 1.—Make the semilunar incision A, B, C (Fig. 1208), the lowest point (B) being about 2 inches below the tip of the trochanter, the pits A and B being about the same distance in front of and behind the posterior and anterior edges of the trochanter, respectively. Divide the skin and deep fascia.

Step 2.—By means of a curved incision corresponding exactly to the skin incision, expose the base of the great trochanter. Continue this incision forwards in a curve so as to penetrate between the anterior fibres of the gluteus medius or between the gluteus medius and the tensor vaginæ femoris. Continue the incision backwards in a curve so as to penetrate between the fibres of the gluteus maximus.

Step 3.—**Method A.**—Pass a Gigli wire saw round the trochanter major and cut through the base of the trochanter from within outwards and downwards.

Method B.—With a saw cut through the base of the trochan without inwards and upwards (Fig. 1209).

Method C.—Make the same division with an osteotome. W method is used, divide the bone obliquely so as to insure easy union.

FIG. 1207.—Kocher's operation. (*Kocher.*)

Step 4.—Reflect upwards the separated trochanter with its muscl exposes the joint thoroughly (Fig. 1210).

Step 5.—Treat the disease as already described.

FIG. 1208.—Ollier's operation. (*Labey.*)

Step 6.—If the trochanter is diseased, re disease or the trochanter itself, as may be i If the trochanter is healthy, return it to it position and fix it there by sutures (wire, ch catgut), pegs, or screws. Provide drainage sary. Close the wounds. Some surgeons joint cavity with iodoform emulsion, Mose or iodoform starch and close without drainag

Rutherford Morison operates as follows: convex incision immediately above the t major. Divide all the muscles inserted trochanter. Dislocate the head of the femu the wound. Remove all the capsule, synov brane, and cartilage from the head and the acetabulum. Close th completely. Immobilize. Do not remove the head of the femur has become a sequestrum.

Remarks.—When coxitis results from osteo-myelitis the treatme to be by excision. While arthrotomy has given good results, yet

leads to a quicker recovery and so avoids the more remote dangers of long-lasting suppuration (Hoffa). When there is hydrops or pyarthros, puncture and injection with some fluid such as formalin-glycerine is advisable unless there is too much absorption of toxins, in which case arthrotomy or arthrectomy is indicated. The hydrops of typhoidal coxitis demands puncture. In tuberculous coxitis when fistulæ are absent and there is no dislocation,

FIG. 1209.

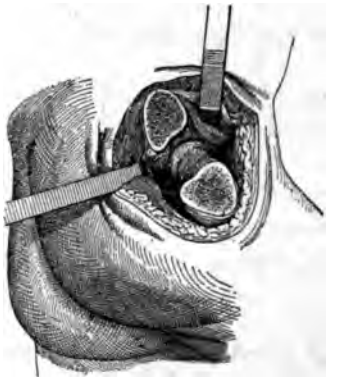


FIG. 1210.

FIGS. 1209 AND 1210.—Ollier's operation. (*Labey.*)

conservative measures ought to be thoroughly tried, especially in the young. When sequestra are demonstrated they must be removed by operation after the failure of conservative measures.

The presence of fistulæ is not *per se* an indication for radical measures, conservative means (suction hyperæmia, Beck's paste, etc.) may be tried if the symptoms are not pressing, but the attempts at conservatism must not be persisted in if improvement does not soon show itself. Even in the presence of well-marked visceral tuberculosis or of amyloid disease it is almost always proper to prefer excision to amputation in severe cases of tuberculous coxitis.

CHAPTER LXXVIII

HIP. ARTHRITIS DEFORMANS

In cases of arthritis deformans of the hip in which there is much disability from pain, muscular spasm, and deformity, F. H. Albee ("Jour. A. M. A.," June 13, 1908) operates as follows:

Step 1.—From a point just below and internal to the anterior superior iliac spine make a 5-inch cut through the skin and subcutaneous tissue along the inner border of the sartorius.

Step 2.—Divide the deep fascia. Retract the sartorius outwards. Penetrate the deep structures by blunt dissection. Retract the iliacus and rectus femoris inwards. Expose the hip-joint.

Step 3.—A large ring of osteophytes generally will be found about the rim of the acetabulum. Turn such upwards with the soft parts adherent to them. This is easily done with chisel and elevator.

Step 4.—Do not attempt to disarticulate the hip, but with the he femur remaining *in situ*, cut away about half its upper hemisphere wi chisel in a plane nearly parallel to the axis of the femoral neck (F In the same manner flatten the upper part of the acetabulum so th surface of femur lies against a flat surface of acetabulum, when the li ducted. Remove the chips of bone.

FIG. 1211.

FIG. 1212.

FIGS. 1211 AND 1212.—Albee's operation.

Step 5.—Abduct the limb and obtain approximation of the su bone made flat by the chisel (Fig. 1212). The position desired is one overcorrection with abduction to overcome the shortening which i present. Before obtaining the desired position open tenotomy of the a at their origins may be necessary.

Step 6.—Suture the capsule and soft parts. Apply dressings. In in a position of abduction.

Albee has used this operation in five cases with gratifying results.

CHAPTER LXXIX

ANCHYLOSIS HIP

Malpositions with bony anchylosis of the hip and certain osseous ties, such as coxa vara, are the principal lesions which necessitate o at the hip. Bony anchylosis may be due to one of several causes—*e.g.* culous osteo-arthritis, fracture of the femur or acetabulum, etc. When a method of operating, the nature of the lesion causing the deformity taken into consideration. An operation which would be safe in a anchylosis due to trauma might, in one due to tuberculosis, relight th process and even cause its dissemination. The choice of operation m depend on whether the result desired is a joint immobilized in good or one capable of movement.

I. **Supra-trochanteric Osteotomy.**—(A) **Subcutaneous with Saw. Operation** (see p. 968).

(B) **Division of the Femoral Neck with Chisel through a Small In** Place the patient on his sound side. At a point immediately above t trochanter make a vertical incision about 1 inch long down to the ne femur. Introduce an osteotome alongside the knife and remove th Turn the edge of the osteotome transversely to the neck of the fe

ivide it completely. Do not, as in the operations for genu valgum, etc., artly divide and partly fracture the bone; this might result in dangerous plintering. Apply dressings. Immobilize the limb in good position by neans of extension, splints, plaster of Paris, or by a combination of these neans. Treat the case as a fracture.

Note.—Division of the neck of the femur is suitable in cases of bony anchy-osis where flexion is the only deformity present. Of course when the head and neck are profoundly altered, *e.g.*, in bad cases of coxa vara or of destructive steitis the operation is often impossible.

(C) **Open operation with introduction of muscle between the cut surfaces of the bone (Nélaton's operation)** (Huguier, Traitement des Ankyloses). Arthroplasty.

Step 1.—From a point one or two fingers' breadth below the anterior superior iliac spine make an incision through the skin and subcutaneous tissue, along the anterior border of the trochanter major. This incision is about 6 inches long. Divide the fascia throughout the length of the wound. Find the interspace between the tensor vaginæ femoris and the sartorius; separate and retract these muscles outwards and inwards, thus exposing the rectus femoris and more deeply the ilio-psoas (Fig. 1213). Strongly retract inwards these two muscles. With the finger palpate the great trochanter and the anterior surface of the articular capsule; expose this latter completely. Split the capsule from the anterior *inferior* iliac spine to the trochanter, preserving the ilio-femoral band as well as possible. By blunt dissection denude the anterior surface of the neck of the femur and expose the junction of the head of the femur with the cotyloid cavity. (These structures are fused together.)

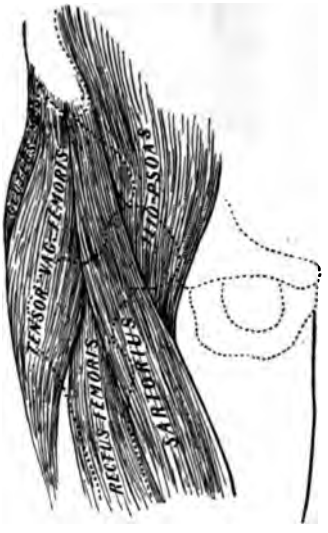


FIG. 1213.

Step 2.—With osteotome and mallet divide the *head* of the femur where it is fused to the pelvis. Preserve as much as possible of the head of the bone attached to the neck. When the bone is divided, clean out the cotyloid cavity with gouge and rongeurs so as to make it concave and smooth. Smooth and round off the remnant of the head of the femur. If the trochanter and neck of the femur are very much deformed and are so anchylosed to the ilium that it is impossible to reform the head and neck of the bone, divide the fused mass; cut a cavity in the iliac bone; see that this cavity is provided with a prominent superior and posterior border; round off the top of the upper end of the femur so that it may fit into the above-mentioned cavity.

Step 3.—The new articulating surfaces having been prepared, interpose a layer of muscle between them as follows: Divide the rectus femoris muscle about 4 inches below its origin, mobilize it, let it fall into the new-formed cotyloid cavity, [redacted] there with a few sutures (Fig. 1214).

Step 4.—Place the femur in position. Close the wound with or w drainage. Apply dressings and extension. Keep immobilized unti wound has healed and then gradually begin exercises.

Rochet has shown that by operating from the front the glutei muscl the strong upper and posterior parts of the capsule are preserved intact. structures prevent the femur from riding up over the ilium. In some where there is much inversion of the thigh, the anterior operation is imp and it becomes necessary to adopt Langenbeck's or Ollier's incision for ex

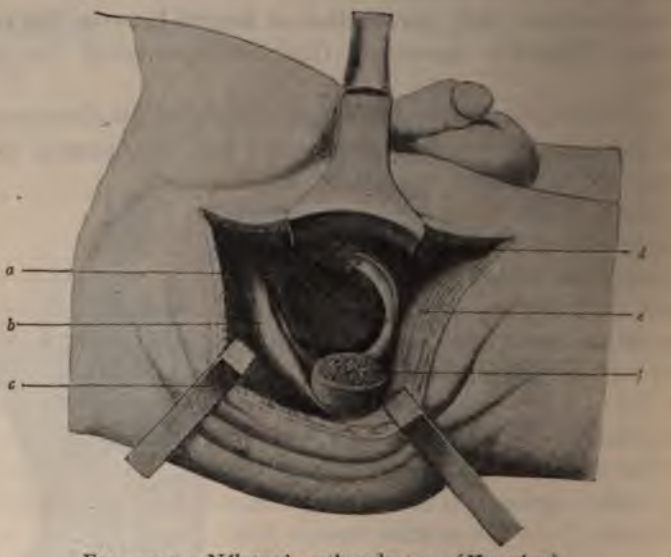


FIG. 1214.—Nélaton's arthroplasty. (*Huguier.*)
a, Flap of rectus muscle; *b*, ilio. femoral band; *c*, tensor fasciæ latæ; *d*, sartorius; *e*, neck of fem

of the hip. The operation so far as exposing the joint is concerned is the as in excision and requires no special notice at this place. The bones are di and treated as in Nélaton's operation, but the muscle flap used for interpo is obtained from one of the glutei.

Murphy's Operation.—J. B. Murphy ("Journ. A. M. A.," May 2 June 3, 1905), reasoning from Langemak's classical researches into the of bursæ ("Archiv für klin. Chir.," lxx, 946) and from some experimen his own, concludes that fascia and fat are more suitable than muscle for position between the ends of the bone after section. In the case of a s boy Murphy operated as follows and obtained a brilliant result:

Step 1.—Make a **V**-shaped incision, with the trochanter in the cen the **V**, reaching from a point 4 inches above to a point 2 inches below th chanter. The open end of the **V** is 5 inches wide and directed upwards. R upwards the **V**-shaped flap containing skin, superficial fascia, and fasci (Figs. 1215 and 1216).

Step 2.—With a needle and guiding suture, pass a Gigli wire saw the base of the trochanter major and divide it transversely. This m

FIG. 1215. FIG. 1216.

FIG. 1215 AND 1216.—Result of arthroplasty. (*Murphy.*)

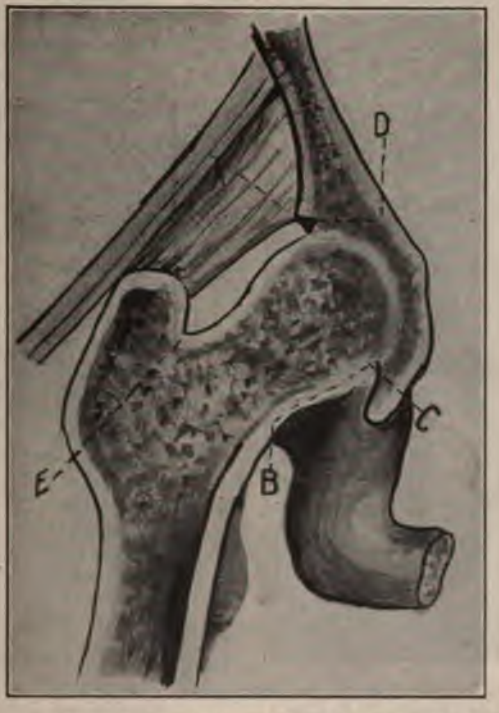


FIG. 1217.—Arthroplasty. (*Murphy.*)

an osteotome. Turn the severed trochanter with its attached
wards (Figs. 1217, 1218 and 1221).
–Incise the articular capsule and separate it from the ilium all the

–Chisel the bony material (head of femur and new bone) filling the
ı from the latter, beginning at their line of junction and so cutting
ch as possible of the femoral head is retained (Figs. 1222 and 1226).
ng most of the line of union, the remainder may be fractured by
: thigh.
–With chisel, rongeurs, and scoop, smooth and deepen the cotyloid
milarly round off and smooth the head of the femur.

221.—Trochanteric muscles re-
wards. Joint opened. (*Guillot*
y, J. de Chir.)

FIG. 1222.—Separation of anchylosed bones.
(*Guillot and Dehelly, J. de Chir.*)

–Dissect the fascia lata from the rest of the original V-flap leaving
tact. With this fascial flap, line the new cotyloid cavity. Fix the
in position by a few sutures. Only a part of the flap and that near
required for this purpose, the apical portion will be used to cover
By manipulations return the head of the femur into the socket
. Suture the free margin or apical portion of the fascial flap to the
. and capsule attached to the neck of the femur. This is important, as
onsiders it essential that every part of the new articulating surfaces
with fascia.
–Peg or wire the divided trochanter major in its old position. Close
. Dress and apply extension.
-It may be necessary to [redacted]m tenotomy on one or several muscles
ercome their contracti[redacted]e a good position is obtained. (Figs.
and 1227 show the r[redacted]se of Murphy's.)

The series of illustrations published by Guillot and Dehelly (J. de Chir. March, 1914) are so much more illuminating than words or than Murphy's

FIG. 1223.—Reaming acetabulum. (*Guillot and Dehelly, J. de Chir.*)

FIG. 1224.—Fascial flap made to line acetabulum. (*Guillot and Dehelly, J. de Chir.*)

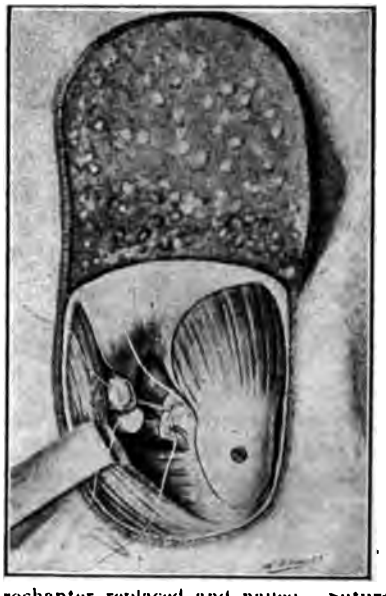


FIG. 1225.—Mobilized trochanter replaced and nailed. Suture of divided structures. (*Guillot and Dehelly, J. de Chir.*)

own figures that they are included here and may almost take the [illegible] scription in the text. Figs. 1219 to 1225.

II. Trochanteric Osteotomy.—Rhea Barton (Philadelphia) was the first to correct deformity in hip anchylosis by osteotomy. His line of section was through the trochanter major (Fig. 1228). This operation is not performed now.

III. Intertrochanteric Osteotomy.—Sayre's Operation.—*Step* 1.—Make a vertical incision from a point just above the tip of the great trochanter downwards for 6 inches along the mid-line of the outer surface of the femur. From the middle of this incision make a transverse cut directly backwards for a short distance.

Step 2.—Expose the anterior, outer, and posterior surfaces of the upper end of the femur by means of the periosteal elevator until the trochanter minorcan be felt.

Step 3.—Pass a chain or Gigli wire saw around the femur between the major and minor trochanters. (a) Make a Λ or Ω-shaped section of the bone (Fig. 1229). Divide the upper end of the lower fragment transversely, removing a segment of bone one-eighth of an inch thick at its outer and inner margins. With chisel and forceps round the upper end of the lower fragment so as to fit into the cavity in the upper fragment.

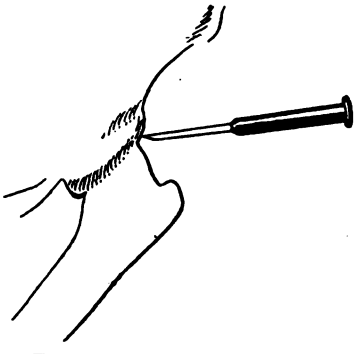


FIG. 1226.—Anchylosis of hip.

Step 4.—Close the wound and treat as a compound fracture. Sayre's object was to obtain a mobile joint, but one can hardly expect much success from the original operation. The author suggests the following modification of the Sayre method:

Step 1.—Make a V-shaped incision having the trochanter midway between its anterior and posterior limbs, reaching from immediately above to a point about 5 or 6 inches below. The open end of the V incision is directed upwards and the distance between the two vertical portions of the V is about 2½ to 3 inches. Reflect upwards the V-shaped flap which must consist of skin, subcutaneous tissue, and fascia lata (as in Murphy's operation).

Step 2.—Pass a Gigli wire saw around the femur between the two trochanters and divide the bone transversely (the division may be made with an osteotome).

Step 3.—With a gouge and rongeurs excavate a bowl-shaped depression in the mass of fused bone (trochanter major, head and neck of femur and ilium) which represents the anchylosed hip.

Step 4.—Separate the fascia lata from the reflected V-shaped flap, leaving it attached by its base. With this flap line the new-made cotyloid cavity.

Step 5.—With rongeurs, etc., round off the upper end of the lower fragment of femur and fit it into the new cotyloid cavity.

Step 6.—Close the wound. Apply dressings and extension. When the wound is healed begin motion.

IV. Subtrochanteric Osteotomy.—Advantages over the supra- or intertrochanteric operation: (*a*) Ease in performance. (*b*) Remoteness from articulation (important in tuberculous disease). (*c*) Section is below insertion of [illegible]cle. If this muscle could act on the lower fragment it might cause mal-position.

(A) **Transverse Linear Subtrochanteric Osteotomy (Gant's Operation).**—*Step* 1.—At a point four fingers' breadth below the tip of the great trochanter over the external surface of the femur make a vertical incision down to the bone. The incision must be of sufficient length to permit the easy introduction of an osteotome.

Step 2.—Introduce the osteotome with its cutting edge parallel to the wound; when the osteotome reaches the bone, turn it so that its cutting edge becomes transverse to the long axis of the bone. Cut through the bone as in supracondyloid osteotomy (Fig. 1230).

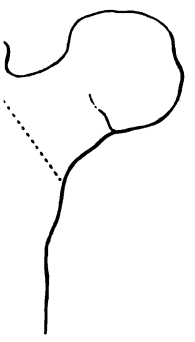
FIG. 1227.—Arthroplasty. (*Murphy.*)

Step 3.—Remove the osteotome. It is usually unnecessary to insert sutures. Place the limb in good position. Apply dressings and extension.

N. B.—The bone section may be made with an Adams's or Jones' saw instead of with an osteotome.

(B) **Oblique Linear Subtrochanteric Osteotomy (Terrier, Hannequin).**—*Step* 1.—Make a vertical incision 5–6 inches in length along the middle of the outer surface of the femur from the top of the trochanter major downwards. Separate the periosteum from the bone over its anterior and external surfaces corresponding to the line of section of the bone.

2.—With an osteotome or chisel, cut a groove across the outer surface emur immediately below the great trochanter. This groove prevents of the osteotome when the oblique section is begun. Using this groove rting-point, divide the bone obliquely from above downwards and in-



8.—Rhea Barton's osteotomy.

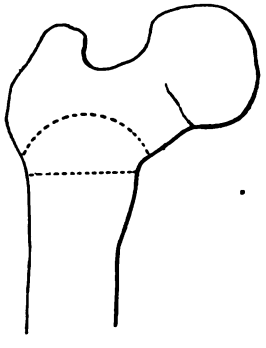


FIG. 1229.—Sayre's osteotomy.

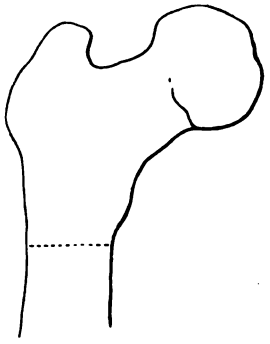


FIG. 1230.—Gant's osteotomy.

The antero-posterior plane of section ought not to be exactly straight at to be slightly oblique from in front backwards and inwards. This tter apposition of the fragments when extension is applied (Figs. 1231 2).

FIG. 1231.

FIG. 1232.

FIGS. 1231 AND 1232.—Oblique osteotomy. (*Hoffa.*)

advantage [illegible] gained from the obliquity of section is that, when ortening [illegible] mb is present, extension may cause the divided sur- slide on ea[illegible]nd thus give some lengthening while the fragments ain in app[illegible]

(C) **Linear Oblique Trochanteric Osteotomy (Berger's Operation)** operation is almost identical with the preceding, but the line of secti shown in Figs. 1233, 1234. The technic of Berger's operation is

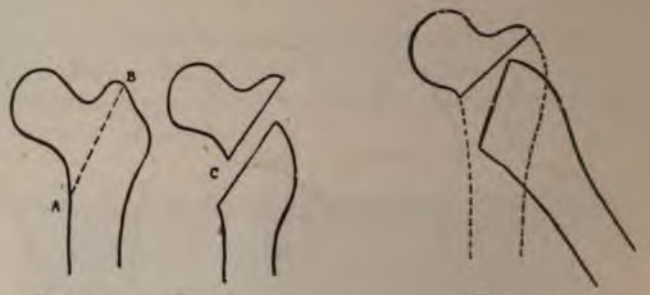


FIG. 1233. FIG. 1234. FIG. 1235.

FIGS. 1233, 1234 AND 1235.—Oblique trochanteric osteotomy. (*Jones.*)

but the use of Jones' saw greatly simplifies it as the hook at the end blade prevents transfixion of the tissues and also prevents the saw e from its groove in the bone. Robert Jones has frequently performe operation with complete success in cases where besides flexion there wa

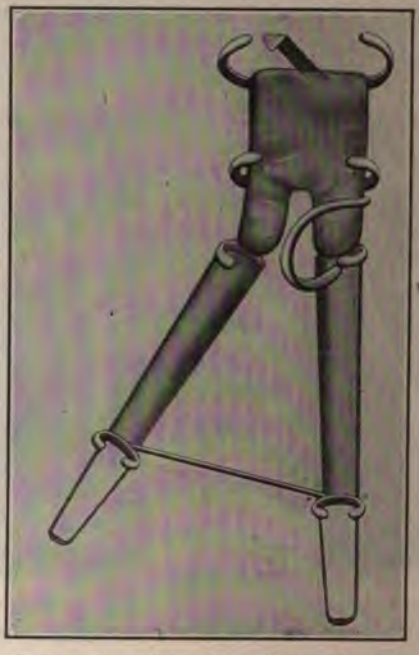


FIG. 1236.—Abduction splint. (*Jones.*)

adduction with pelvic tilting. After dividing the bone he cuts the ad subcutaneously and in the case of a youth or adult applies traction by of pulleys. By this traction an inch or more of *true* lengthening may o

obtained (Fig. 1235): After applying proper dressings he places the leg in an abduction splint (Figs. 1236 and 1237), which is arranged so as to keep up the extension. The degree of abduction desired depends on the amount of shortening and of pelvic tilting, *i.e.*, the amount of true shortening. Fig. 1238 shows clearly how ***abduction*** may, by tilting of the pelvis, give apparent lengthening to a truly shortened limb. The patient must be kept in the splint for seven or eight weeks or until bony union is complete. Jones, following his uncle, H. O. Thomas, and Rushton Parker, does not fear dividing the bone through inflamed tissue when this is necessary. After bony union is secured and the splint removed the limb should be allowed to leave the abducted position slowly, and exercise should be prescribed to depress the pelvis on the affected side and so obtain *apparent* lengthening of the short limb.

FIG. 1237.—Abduction splint. (*Jones.*)

(D) **Cuneiform Subtrochanteric Osteotomy.**—*Step* 1.—Make a 2- to 3-inch vertical incision over the external surface of the femur, having its middle at a point about four fingers' breadth below the tip of the trochanter major. Retract the edges of the wound and reflect the periosteum over an area involving the width of the bone.

Step 2.—With chisel and mallet excise a wedge of bone. The wedge must of course be so placed as to correct the deformity, *e.g.*, if there is a deforming degree of flexion the base of the wedge must be on the posterior surface of the bone; to correct adduction the base of the wedge must be external (Fig. 1239). A modification of cuneiform is trapezoidal osteotomy and is sufficiently ex-

[redacted]240 and 1241.

[redacted]n the bone. Introduce a few sutures. Apply dressings.

Whitman advises cuneiform osteotomy at the level of the lesser trochanter in young children with coxa vara. He writes: "In childhood the neck of the femur is short and the strain to which it is likely to be subjected slight, thus operative treatment may be indicated as a prophylactic measure while in adolescence operative treatment may be deferred until the progression of the de-

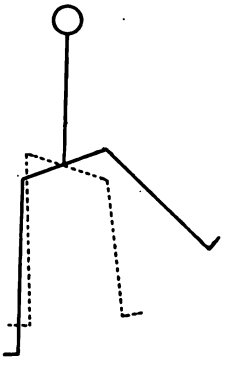


FIG. 1238.—Diagram showing how abduction gives apparent lengthening to a limb.

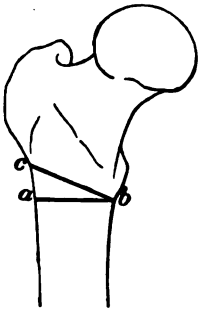


FIG. 1239.—Cuneiform subtrochanteric osteotomy. (*Berger and Banzet.*)

formity has ceased. In the technic of this procedure there are several points of importance. First, all restriction of abduction of ligamentous or muscular origin, must be overcome by vigorous manipulation before the operation on the bone, otherwise it will be difficult to bring the two fragments into proper apposition. The base of the wedge should be about three-quarters of an inch in breadth, directly opposite the trochanter minor; the upper section should be practically at a right angle with the shaft, the lower being more oblique (Fig.

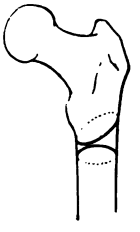


FIG. 1240.

FIG. 1241.

FIGS. 1240 AND 1241.—Trapezoidal osteotomy. (*Berger and Banzet.*)

1242). The cortical substances on the inner aspect of the bone should not be divided, but, reinforced by the cartilaginous trochanter minor, should serve as a hinge on which the shaft of the femur is gently forced outwards, until the opening is closed by the apposition of the fragments after the upper segment has been fixed by contact with the margin of the acetabulum (Fig. 1242), thus the continuity of the bone is preserved. The leg is then held in the attitude of extreme abduction, by means of a plaster spica bandage, which must include the foot also, until the union is firm.

"The opportunity for treatment of coxa vara, in early

ffered. It is usually the direct result of rachitis, and in the early stage, at **east,** it is probably accompanied by other rachitic distortions. It would be **vell, therefore,** to examine the hip-joints of rachitic children, especially those **vho** present the deformity of genu valgum with reference to this distortion."

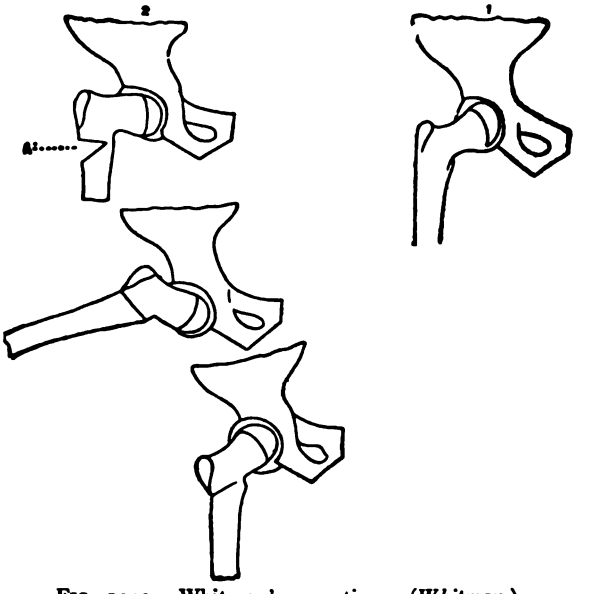


FIG. 1242.—Whitman's operation. (*Whitman.*)

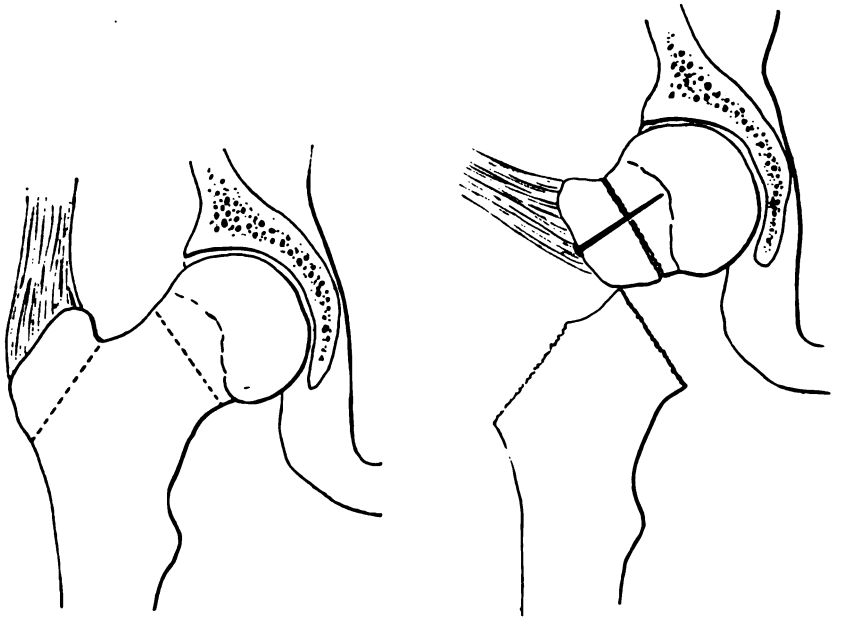
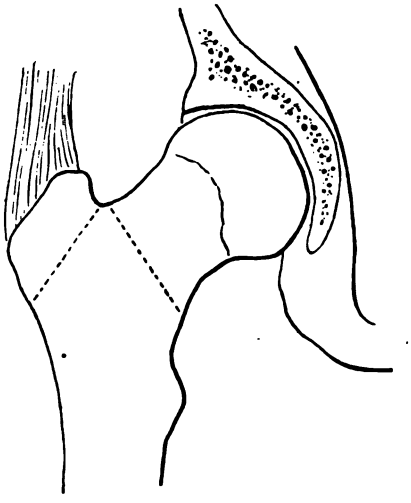


FIG. 1243. FIG. 1244.

FIGS. 1243 AND 1244.—R. Jones' operation. (*Jones.*)

Jones's Operation.—In bony anchylosis of the hip following tuberculosis **or** sepsis and in certain forms of coxitis, *e.g.*, malum coxae senilis, where the

body weight acting on the head of the bone, and articular friction l
disease active, Robert Jones produces a pseudo-arthrosis without disarti
the head of the femur. The operation produces much less shock than
cision of the head of the bone and in suitable case has given excellent fu
results.



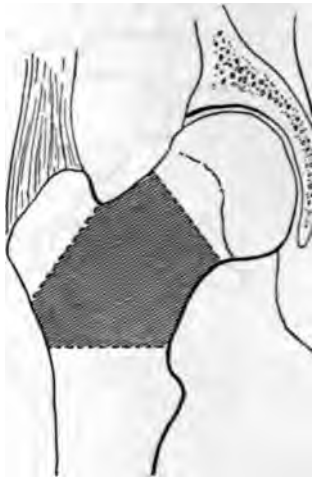


FIG. 1245. FIG. 1246.

FIGS. 1245 AND 1246.—R. Jones' operation. (*Jones.*)

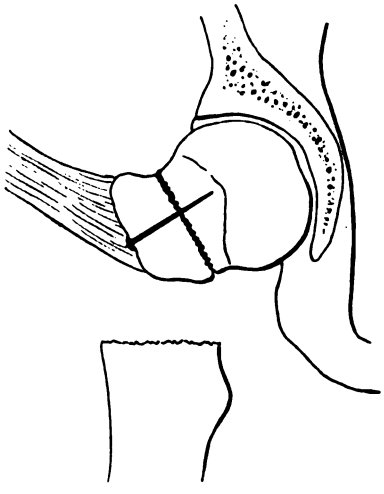


FIG. 1247.—R. Jones' operation. (*Jones.*)

Step 1.—Make a 6-inch longitudinal incision along the outer surfa
upper end of the femur. One-half of the incision is above the mid-poi
upper border of the trochanter major and one-half is below. This
lower half penetrates to the periosteum or bone. Retract the soft p

Step 2.—Incise the periosteum transversely at the base of the t
just below the insertion of the gluteal muscles. From this line cut thr

trochanter to its junction with the femoral neck, using a saw or a wide osteotome (Fig. 1243). Retract the separated trochanter upwards.

Step 3.—Open the joint. Divide the neck of the femur near the head of the bone with an osteotome (Fig. 1243).

Step 4.—Exert strong extension on the femur. Apply the cut surface of the separated trochanter to the cut surface of the neck of the femur and fix it there with a screw nail (Fig. 1244). This fixes the trochanter to the head of the femur which is still in the acetabulum.

Step 5.—Close the wound with deep and superficial sutures. When there is much tenderness it may be necessary to remove a section of the neck instead of merely dividing it, so as to avoid "impinging." "In the case of an anchylosed sound joint following sepsis it may be advisable, instead of dividing the neck near the acetabulum, to divide it near the trochanter (Fig. 1245)." Where there has been much injury due to disease more bone may be removed as shown in Figs. 1246 and 1247.

CHAPTER LXXX

OLD DISLOCATIONS OF THE HIP

When a dislocation of the hip has remained unreduced for a few weeks it has become practically irreducible by manipulation alone. Even recent dislocations may resist manipulative reduction. The principal conditions or lesions preventing reduction are: (*a*) The filling of the cotyloid cavity with fibrous tissue which often becomes osseous. (*b*) The interposition between the femur and the acetabulum of shreds of capsule, fascia, muscle, etc., to which may be attached fragments of bone torn from the trochanter or broken off the rim of the acetabulum.

(*c*) Changes in the shape of the head of the femur due to its adaptation to new surroundings, also fixation of the femoral head in a new-formed acetabulum.

(*d*) The femoral head may be grasped tightly in a collar formed by the small external rotator muscles.

(*e*) The muscles, ligaments, and fascia surrounding the dislocated bone adapt themselves to their new conditions, hence they are contracted or shortened in places and so obstruct reduction.

(*f*) Fractures of the head of the bone and even of the shaft seriously interfere with reduction.

I. **Posterior Dislocations.—Method A.**—*Step* 1.—Make a 5-inch incision over the region of the acetabulum along the posterior portion of the trochanter major (Fig. 1248). Divide the tissues attached to the posterior margin of the trochanter; while doing this hug the bone.

Step 2.—Expose and clean out the acetabulum. If necessary for reduction remove the parts of posterior wall of the acetabulum with chisel or rongeurs. [redacted] reduction and provides for drainage.

osen the head of the femur from its surroundings by manipula-
section, and, if necessary, by sharp dissection.

Step 4.—Reduce the dislocation by manipulation of the limb and by pressure, etc., on the head of the bone.

Step 5.—Provide for drainage. Close the wound. Dress. Appl tension. While operating remember that the great sciatic nerve is som picked up by the dislocated femur and passes as a tight band over th of the bone (Fig. 1249) and is thus in distinct danger.

Method B.—A. von Bergmann ("Archiv für klin. Chir.," lxix. 592) r the use of Larghi's incision in cases of the old hip dislocation whether tra or congenital in origin.

Step 1.—Make an incision parallel to, and immediately below the crest illium from the posterior inferior, past the anterior superior spine to the anterior inferior spine between the tensor vaginæ femoris and sartorius muscle. This exposes the origin of the gluteus maximus and medius.

FIG. 1248.—Exposure of dislocated hip. (*After Hoffa.*)

FIG. 1249.—Posterior dislocation Sciatic nerve stretches over neck of (*Allis.*)

Step 2.—Corresponding to the skin incision, divide the gluteus ma medius and minimus close to their origin, but preserve the periosteum un top of the sciatic notch is reached; at this level divide the periosteum and it also downwards along with the overlying soft parts (this preserves the su gluteal artery from injury). Continue the dissection or separation down subperiosteally until the acetabulum is well exposed.

Step 3.—After exposure of the acetabulum, separate the soft parts fro trochanters by division, under guidance of the eye, of the muscular inse To do this various manipulations of the thigh are necessary so as to prominent the dislocated head of the femur.

Step 4.—Examine the acetabulum. If necessary prepare it for the re

f the head of the femur. By manipulation and traction reduce the dislocation. 'arious tenotomies may be necessary to permit of reduction.

Step 5.—Close the wound with or without drainage. Dress.

Method C.—Cheyne and Burghard recommend anterior arthrotomy. M. Harris uses the same route. In one case Spencer found that it would have en impossible to reach and clear the acetabulum through a posterior incision thout resecting the head of the femur.

Step 1.—Make a 4-inch incision downwards and forwards from just beneath e anterior superior spine and between the tensor vaginæ femoris and the rtorius.

Step 2.—Separate the above-mentioned muscles and so expose the region of ie head and neck of the femur. "In order to get satisfactory access to the cetabulum, it will generally be found necessary to detach some of the muscles om the ilium. Division of the tensor vaginæ femoris and the anterior part of ie gluteus minimus may be necessary, as they will probably be somewhat ortened."

Step 3.—Incise the joint capsule near its insertion into the neck of the femur. ivide the Y-ligament and obstructive bands. Clean out the acetabulum.

Step 4.—Reduce the dislocation. It may be necessary to divide the tendon the obturator internus before success is attained. Close the wound without ainage if hemostasis is complete and asepsis assured; if necessary posterior ainage may be provided.

After-treatment.—Whatever method of operating is chosen, extension by ight and pulley should be applied. At an early date begin gentle passive tion. As soon as the wound has nearly healed, change the direction of the tension from day to day; *e.g.*, at first the extension is directly in the line of e body, change it so that the hip is slightly flexed, then make the extension in ch a manner that there is a little abduction, and so on, changing the position ghtly every day. Passive movements must be employed daily, unless signs inflammation are present in the wound. At as early a period as possible ter healing of the wound is complete, active movements should be initiated. o much importance cannot be placed on thorough after-treatment.

II. **Anterior Dislocations.**—Perhaps the most practical way to describe the erative reduction of anterior dislocations will be to give a résumé of a case erated on and reported by Endlich ("Archiv für klin. Chir.," lvi, 585). ale, thirty-seven years of age. Obturator dislocation of three months' dura- n. Incision along the lower (posterior) edge of the gracilis from the mphysis pubis downwards. The head of the femur was reached after the ductors were penetrated. The femoral head lay in a very firm capsule of rous tissue containing many fragments of bone.

Owing to the depth of the wound and density of tissues the bone could not freed sufficiently. The patient was turned on his right side. Langenbeck's cision, six inches long, was made, beginning below the trochanter major and nning upwards and backwards towards the *posterior* superior iliac spine. Af- r penetration of the gluteal muscles the acetabulum was reached and found led with firm fibrous tissue which was removed. The femoral head lying in nt of the acetabulum was freed from the adherent soft parts by blunt and sharp

dissection. Much scar tissue containing shell-like fragments of bone wa moved. After removal with the chisel of a portion of the anterior edge of the loid cavity opposite the femoral head, reduction by manipulation was succe Both wounds were loosely packed with gauze. Dressings and extension ap The result was at first disappointing, but poverty forcing the patient (a lab to work, his hard labor proved the best after-treatment and the outcome most gratifying. In such a case as the above it probably would be bett omit the first (internal) cut made by Endlich and content one's self wit Langenbeck incision.

Dislocation of the Hip Complicated by Fractures.—Fracture of the of the femur complicating dislocation may hinder reduction by preventin use of the bone as a lever, and thus compel operation.

When there is extra-capsular fracture of the neck of the femur, expos bone, if possible reduce the dislocation, and then treat the fracture *secu artem* (preferably by the application of a buried metal splint). If reducti the dislocation is impossible or improper, the separated head of the bone be excised, or if it is causing no pressure symptoms and will apparently n terfere with the ultimate result it may be left *in situ*, the surgeon aimi obtain a useful pseudarthrosis.

Intracapsular fracture complicating dislocation usually calls for ex of the head of the bone.

When operative reduction is impossible or seems too severe a tax o patient, excision of the head of the bone may be indicated. Osteotomy be practised instead of excision. The aim of this operation is to correct abling deformity and it may be performed in such a fashion as to provide a joint (see Osteotomy). Reduction when proper is of course the operati choice. Excision is preferable to osteotomy when the displaced bone is ca symptoms, *e.g.*, pain and paralysis from pressure. Osteotomy may be p able in the absence of the above troubles and when it is doubtful if the pati strength is equal to the strain involved in the operation of excision, and disabling deformity is present resulting from the malposition. Somet the malposition may be corrected to a practical extent by non-operative t ment. This is well worth trying. When the dislocated head is not ca pressure symptoms and when after exposure reduction is impossible, it is always necessary to excise the head of the bone. "The best thing is prob to try and form a new acetabulum upon the iliac bone, in the new position the head of the bone occupies, and to so substitute a stable and movable j for the unstable and useless one resulting from the dislocation. To do th portion of the pelvis is gouged away opposite the head of the bone unt shallow bed is formed in which the head can lie. Instead of removing portions of bone so raised, it is well to simply gouge them upwards and then b them at right angles to the pelvis, so that they form a sort of buttress, venting the head of the bone being pulled farther up. In the course of a weeks considerable callus is thrown out around the portions of bone deta in this way, and thus an obstacle to the further dislocation of the hea obtained" (Cheyne and Burghard).

CHAPTER LXXXI

CONGENITAL LUXATION OF THE HIP

GWILYM G. DAVIS AND F. D. DICKSON

There are some affections which, without doing special harm, the practising physician or general surgeon can deliberately ignore and relegate to the care of the specialist, but a congenital luxation of the hip is not one of them. Although the treatment can be intrusted to the specialist, it is incumbent on those who first see these cases to recognize their serious character, and this in too many cases they fail to do. The affection is a frequent one; its manifestations are obscure, especially in its early stages; untreated it never undergoes spontaneous cure, but progressively gets worse, deforming and even disabling the patient. Failure to recognize the affection and delay in instituting treatment increase the difficulty of remedying it and may even render the patient a permanent and more or less helpless cripple. For these reasons the general physician and surgeon should have a sufficient knowledge of it to enable him to suspect and possibly diagnose its presence and inform the parents as to the course to be pursued in having it properly treated.

Etiology.—The cause of this affection is unknown. In some cases the luxation is produced at the time of birth, but few, however, can be accounted for in this manner; in some heredity seems to play a part; intra-uterine disease has also been held to be a factor, but this has not been generally accepted. Retarded development does not account for it. Perhaps the most favorably received theory is that the luxation is the result of slowly acting force exerted during intra-uterine life. This is supposed to occur in cases in which there is a lack of amniotic fluid, thus allowing the uterine walls to act more directly and forcibly on the extremities. Codivilla states that they are flexed, adducted and rotated inwardly. This condition existing for a considerable time destroys the stability of the joint and favors anatomical changes; the capsule becomes relaxed, the acetabulum shallow and the upper end of the femur altered. The preponderance of the affection in females—six or seven to one—is explained by the sexual anatomical differences in the pelvis, which begin to manifest themselves as early as the fifth month of intra-uterine life.

Prognosis.—Some surgeons appear to consider congenital luxation of the hip as not a very serious affection, but with this we cannot agree. It is deforming, painful, disabling, and greatly interferes with the patient's usefulness and ability to earn a livelihood. The affection is least marked at birth. There is no pain and usually it is only when the child begins to walk that the trouble is recognized. The gait of a one-sided luxation is a marked limp; of a double, a distinct waddle. Soon the back becomes hollow. Perhaps for several years the patient may go about in this condition, deformed and limping, somewhat disabled but still fairly active. As age advances the displacement becomes more marked. Pain, in various degrees, is experienced. Difficulty is found in

going up and down stairs and walking long distances is impossible. A puberty a rapid increase is noted and if compelled to earn their livelihood th patients try to obtain a sitting occupation. Even then they are suffer and from time to time, at least temporarily, are compelled to rest in bed. W there may be intervals when they are free from pain, still they are liable to disabled at any time, and so they pass a more or less miserable existence. pain is at all constant it prevents them from taking a sufficient amount exercise and this with advancing years causes them to take on fat and increas weight which all tends to aggravate their distress, and their condition of becomes pitiable.

Anatomy.—The bony changes are marked. The acetabulum (Fig. 12 is less in size than normal, it loses its round form and becomes narrowed the sides, thus making it longer vertically than in its horizontal axis. T

FIG. 1250.

FIG. 1251.

cartilage becomes thicker, thus reducing the depth of the acetabulum and th fat and fibrous tissue from the region of the cotyloid notch enroach upwards an also help to fill it up. The cartilaginous rim, especially above and posterio atrophies and this together with the filling up of the acetabulum by the fat and fibrous tissues practically, in many cases, obliterates the concavity; hen when the head is replaced it frequently reluxates. Sometimes masses of cart lage and bone are fond in the acetabulum in operative cases; these are co sidered by Lorenz to be out-growths from the posterior wall.

The acetabular changes are frequently found at birth, though they increa with age. In old cases, sometimes, more or less bony out-growths and hollow exist above the acetabulum, which tend to make the articulation more fir and secure.

The femur, also, at its upper extremity (Fig. 1251), while somewhat deform at birth, is still more deformed as age advances. The head is smaller than no mal and flattened on its inner posterior portion. In some cases it is more or le pointed while in others it is markedly flattened, having a somewhat mushroo like shape. The neck shortens, and its angle with the shaft decreases from 13

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There is no turning inwards of the foot such as is present in traumatic luxations. Viewed from the side there will be a hollowness of the back (Fig. 1254), lordosis, due to the tilting of the pelvis forward and an accompanying prominence of the buttocks. In unilateral cases a twisting of the pelvis may be

FIG. 1252.

FIG. 1253.

FIG. 1254.

noticeable, and in order to compensate for the shortening of the affected limb the opposite one may be slightly flexed both at the hip and knee. A tendency to flexion of these joints exists also in the affected limb and particularly so in the older cases of double luxation; when the patient stands upright, flexion of both hips and knees may be marked. This is due to the tilting of the pelvis forwards.

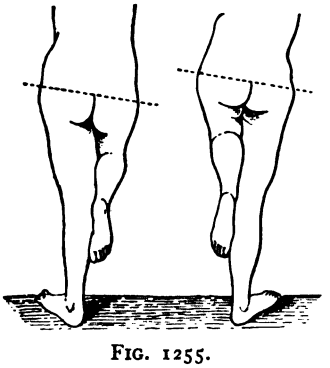


FIG. 1255.

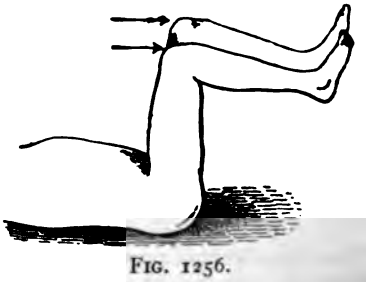


FIG. 1256.

Viewed posteriorly the increased breadth across the pelvis from one trochanter to the other is noticed (Fig. 1252); the trochanters are prominent and the buttock beneath flattened. In unilateral luxation the gluteo-femoral fold of the affected side is lower than that of the sound side, and the trunk is also inclined towards the affected side. Trendelenburg has pointed out that if the child stands on the sound leg and flexes the affected one the lines of the folds of the

buttocks will remain nearly level (Fig. 1255), whereas if it stands on the affected limb and flexes the sound one the gluteal fold on the sound or flexed side will drop. This is due to the increased tilting of the pelvis in the latter case.

On more closely examining the patient it will be found that by actual measurement in unilateral cases there will be a shortening on the affected side which is considerable and in old cases may amount to one and a half to two inches. It is rendered apparent by adopting Allis's procedure of having the patient flat on the back and flexing the knees and hips to a right angle, the knee of the sound side will be seen to project far above that of the affected side (Fig. 1256). If the patient is seated on a chair in front of the examiner one knee can be both seen and felt to be considerably in advance of the other. To determine the location of the shortening it is necessary to compare a bony landmark of the femur with one on the pelvis. For this purpose the upper edge of the greater

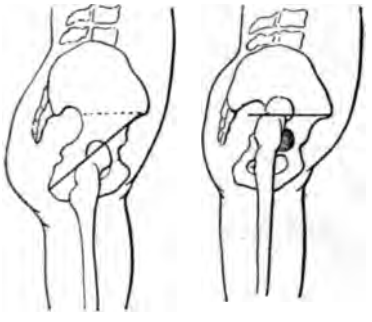


FIG. 1257.

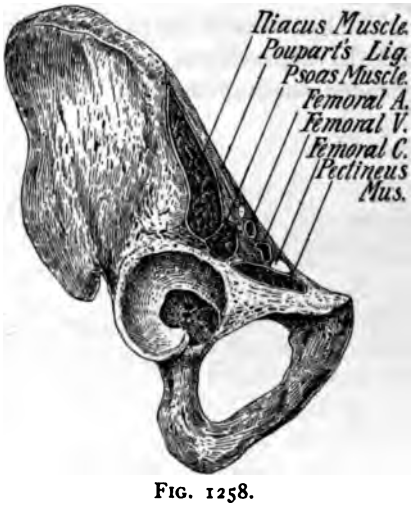


FIG. 1258.

trochanter and the anterior superior spine of the ilium are used. If the measured distance from the tip of the greater trochanter on one side to the corresponding external malleolus is the same as that of the opposite side while the distances from the anterior superior spine to the internal malleolus on the two sides differ, it is evident that the cause of this difference is located above the greater trochanter and that it lies higher than normal. This may be due to either dislocation, fracture, or disease affecting the head and neck of the bone. Normally, the upper edge or tip of the greater trochanter lies almost exactly on a line drawn from the anterior superior spine to the tuberosity of the ischium—Nélaton's line (Fig. 1257). In congenital luxations, the upper edge of the trochanter is considerably above it, proportionate to the amount of shortening. Normally, the upper edge of the trochanter lies obliquely downwards and backwards from the anterior superior spine, but in these luxations it is usually opposite the level of the anterior spine and sometimes above it. [redacted]ay be called the iliotrochanteric angle is lessened or even abolished[redacted]n of the head of the bone should be identified. [redacted]lly, it [redacted] lying beneath the femoral artery just below

Poupart's ligament. The artery crosses the femoral head a little internal middle (Fig. 1258). If the hip is grasped between the thumb anterior fingers posteriorly, the thumb being just external to the artery, by r the limb the head can be felt moving under the thumb. In luxatio head is displaced posteriorly, upwards and outwards. So deep is it th more readily recognized by the fingers which are posterior than by the which is anterior; this is especially the case when the limb is markedly r inwards. The range of motion of the luxated hip is increased in add while it is decreased in abduction. The lessened abduction is usually marked as in coxa vara (a lessening of the angle between the neck and although in some cases a condition of coxa vara may be present in whi abduction would be markedly restricted. Adduction may be so much inc as to allow the thigh of the affected side to be brought across the groin opposite one.

The looseness of the joint may be demonstrated with the child lying back, having its limbs either extended or flexed. If the limb to be exami extended, the surgeon grasps the two sides of the pelvis with his hands to

FIG. 1259.

On the suspected side the thumb is placed on the anterior superior spine the index finger touches the top of the greater trochanter. An assistan grasps the leg and alternately pulls it down and pushes it up. If the luxated the greater trochanter will be felt sliding up and down.

In examining the limb in a flexed position (Fig. 1259), a method valua children, the knee is grasped with one hand and the thigh flexed to a right The thumb of the other hand is placed in front of the anterior spine an fingers beneath the trochanter. On pushing and pulling the femur wit hand the greater trochanter is felt with the other to slide up and down o side of the pelvis. Sometimes in examining these congenitally luxated h this manner a distinct grating or cracking can be felt.

While one is usually able to diagnose the condition by the physical e nation, it is nevertheless desirable whenever possible to have a skiagraph This will enable one to judge with exactness the height of the head in re to the acetabulum and to a less extent the amount of anteversion of the nec may give considerable information concerning the formation of both the and upper end of the femur as well as the acetabulum. It will not, ho enable one to detect a posterior displacement. Fortunately, this latter is a always associated with a certain degree of upward displacement which c

recognized, and a posterior displacement can usually be detected by a careful physical examination.

Treatment.—In 1826 Dupuytren stated that cure of congenital luxation of the hip was impossible, but advised a pelvic girdle as a palliative measure. Later Landerer used a corset to counteract the lordosis and Langgaard devised a brace which was fastened about the pelvis, passed down the thigh and possessed a pad which made screw pressure over the trochanter.

Attempts at immediate reposition were made by Humbert, but were not successful, and the subject was brought into prominence by C. G. Pravaz, of Lyons, in 1847. Instead of the rapid traction of Humbert, he used strong continuous traction for four to eight months and then by means of extension, abduction, and strong pressure by a large roll under the trochanter replaced the head. Reluxations he treated by repeated replacements. His results were not sufficiently good and his methods were abandoned, only to be revived by Buckminster Brown of New York, who was followed by Bradford of Boston, Adams of London, and others. The extension treatment was brought to its greatest perfection by Max Schede and Mikulicz in 1894, both of whom obtained fairly good results.

The operative treatment began about 1840 with Guerin who tenotomized the muscles attached to the greater trochanter. He was followed by Brodhurst, Bouvier, Barwell, Pravaz, Jr., Coolidge, and others. Resection of the head by Rose in 1874 and Margary, of Italy, in 1882 proved after a full trial to be unsatisfactory.

The question of operative treatment was finally solved by Alfonzo Poggi, of Bologna, who in 1888 replaced the head of the femur in a newly made acetabulum by open incision. He was followed by Hoffa, who in 1890 and subsequently systematized the technic and caused the operation to be generally accepted. In 1892 Lorenz advocated an incision along the posterior edge of the tensor fasciæ femoris muscle instead of the posterior incision of Langenbeck as used by Hoffa. Hoffa himself later adopted a straight incision along the anterior edge of the greater trochanter. The cutting operation reached its acme in 1894 when it was advised by many in preference to all other measures.

At the International Congress in Rome in 1894, papers were read by Hoffa and Lorenz advocating their cutting operations. Kirmisson and Mikulicz inclined to traction treatment and Paci gave a résumé of the work which he had previously published in the "Archivio di ortopedia" in 1890, 1891, 1892, and 1893. He stated that he had practised his bloodless reposition method in twenty-eight cases, twenty-three of congenital luxation, three of pathological, and two of old traumatic. He claimed good results from it in patients from three to twenty-one years of age. He presented the pelvis of a child of seven years in whom Nota, of Turin, had replaced the hips four months previously. In one of these hips there was practically a perfect result. He also demonstrated his method on a patient before the assembled members.

The effect was magical. From this time forth the bloodless method was taken up and the cutting operation reserved for exceptional cases. The following year Lorenz, of [illegible] brought out his modification of Paci's method, and [illegible] changes have been introduced by various surgeons since that date.

Method of Paci.—("Transactions of Eleventh International Medical Congress," Rome, 1894, p. 378.) Paci, as he himself said, used the ordinary circumduction method which had been systematized in Italy by Fabbri. It was as follows: *First*, flex the thigh well on the abdomen, then push forcibly down on the knee so as to force the head downwards. *Second*, while retaining the limb in the previous position slowly abduct the knee until it is 15 cm.

FIG. 1260.

(6 inches) away from the side of the body. *Third*, rotate externally until the axis of the leg (held at 90° to the thigh) is perpendicular to the long axis of the body. *Fourth*, gradually extend the limb while being held in external rotation.

The extension was carried as far as was possible without the head reluxating. Sometimes the thigh was bent over the edge of the table and force was used, to the extent in one case of breaking the femur. The limb was placed in plaster and weight extension used for four months and then removed and the patient kept on crutches for six months longer.

FIG. 1261.

Lorenz Technic.—(Joachimsthal, "Handbuch der Orthopädischen Chirurgie," vol. ii, 169, etc.) The thigh is abducted until the adductor muscles are tense. These are then ruptured by direct pressure made with the ulnar border of the hand by cutting or sawing movements. In difficult cases abducting and rotary movements are made to mobilize the joint. Also traction may be made, either manual by the surgeon or instrumental or by two assistants pulling on a skein of yarn looped around the malleoli or the condyles of the femur. Counter-traction is made by fastening a sheet to the table while the perineum is protected by a pad of spongy rubber.

Reduction (Fig. 1260) is to be accomplished by having an assistant [illegible] pelvis by pressure on the opposite side; the operator then grasps th[illegible]

one hand, the thumb being posteriorly on the trochanter, and the flexed knee with the other, the thigh being vertical. The trochanter is then pushed upwards and forwards with one hand, while the thigh is lifted (traction) and abducted with the other until it is at right angles to the long axis of the body in the frontal plane or even a little more. If these manœuvres do not suffice, a wedge-shaped block (its edge covered with padding) is placed beneath the trochanter and the abduction is made over this (Fig. 1261).

Hoffa ("Joachimsthal," vol. ii, p. 176) abducted to 90° the flexed and strongly externally rotated thigh. It was moved to and from the body, up and down like a pump-handle ("Pumpenschwengel") until it reached the horizontal.

The Bartlett machine ("Journal of Medical Research," x, 440, 1904), much used in a modified form in Boston, resembles in principle that of Max Schede. By it traction is made with a winch and the femur forcibly abducted to 90°. The limb is then removed from the apparatus and the luxation replaced by manipulation, or attempts may be made to push the head into place while traction is still being made.

R. H. Hibbs ("New York Medical Jour.," April 25, 1908) fastens the patient to a table by two straps passing over the crest of the ilia and down between the thighs, thus fixing the pelvis firmly. Then the leg is extended on the thigh, with the thigh held in adduction and flexion on the abdomen, thus forcing the head below the acetabulum. A metal wedge-shaped block is then brought up through a hole in the table and adjusted, by a ball-and-socket joint, against the trochanter so as to direct the head upwards and forwards. The thigh is then extended and abducted, forcing the head to travel upwards, anteriorly, into the acetabulum. He has used the method in fourteen hips in thirteen children from twenty months to eleven years of age. The limb is put up in varying degrees of flexion and abduction and he "doubts the necessity of any case wearing plaster more than two months, and at the most three, and in many a shorter time." In only one case was there reluxation requiring a replacement.

FIG. 1262.

Author's Pressure Method (G. G. Davis, "American Journal of Orthopedic Surgery," Jan., 1907):

The commonly used means of replacing a congenital luxation of the hip is by the Paci-Lorenz method. This is essentially a lever method, the fulcrum being either the ilio-femoral (Y) ligament, a block, the hand as used by Lorenz, the edge of the table as used by Paci, or a hard roll as used by Pravaz. The accidents accompanying this method have been numerous and are a constant menace. To avoid them and yet to apply the requisite amount of force the writer substitutes direct pressure for leverage. It is applied as follows: The [redacted] is placed on the table face downwards with the pelvis resting on a sand-bag [redacted] hanging down over the edge of the table. If the table is well

padded the sand pillow may be dispensed with. The thigh is then
and brought *close to the body* of the patient, the knee being flexed,
there either by the operator (Fig. 1262) or by assistant (Fig. 12
operator then places the base of the palms of his hands on the
and head and makes downward pressure aided by the weight of his b
this means the head is forced from its posterior to an anterior positi
easy cases, the reduction is practically complete, sometimes taking
the usual jump or click. If the case is more difficult and more ab
required, the patient may be brought more towards the middle of th
that the knee and part of the thigh are supported by its edge and pres
applied. Still more abduction can be obtained by placing a pad
beneath the knee so as to elevate it still more (Fig. 1264). By t
hyperabduction (beyond the frontal plane) can be obtained if desi
head being low down the thigh may still be in a position of marked fl
is then flexed and extended by the pump-handle movement of Hoffa
at right angles to the long axis of the body when the plaster cast can b

FIG. 1263.

FIG. 1264.

The limb can be placed in either external or internal rotation. If
then the cast extends below the knee. Traction and tearing or cutt
muscles are not practised because unnecessary, although in an exc
difficult case tenotomy of the adductor longus might be of serv
method has been used in about fifteen cases. In one, age sixteen
failed. In another, aged twelve years lacking one month, it took four
to get a satisfactory amount of abduction. In the others, from t
and one-half years, satisfactory reduction was accomplished at a sing

Fixation: Applying the Plaster Bandage.—Reduction having
complished, the child is turned on its back and placed on a pelvi
(Fig. 1265) with the limbs in the desired position, either projecting ou
angles to the body or flexed or adducted to the extent desired. W
limb up in extreme abduction for the first dressing and invert it a
the abduction at the second dressing. A strip of flannel bandage
the leg next the skin, long enough to project considerably beyond
of the plaster. This is to be used for cleaning purposes, being pull
fro at intervals while the bandage is being worn.

The limb and pelvis are covered either with a flannel bandage or s
and felt pads placed on the sides of the pelvis and inner surfaces of th

avoid pressure sores. The plaster bandage is then applied in the form of a spica embracing the thigh and pelvis. If internal rotation is desired, the plaster must include a part of the leg below the knee. In order to strengthen the bandage and prevent reluxation a strip of strap-iron can be placed in the posterior part of the bandage running down from the pelvis to the thigh. Felt pads can be placed beneath this strip between it and the trochanter so as to force and maintain the head as far anterior as is desired (Fig. 1266). If both limbs are placed in internal rotation as suggested by Schede and advised by Mueller the patient sleeps on a suspended or supported Bradford frame (Fig. 1267) with the legs hanging down over its sides. If only one side is involved the patient can sleep on an ordinary bed with the leg hanging over its edge.

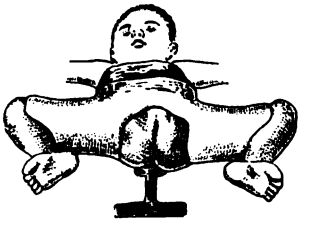


FIG. 1265.

The first plaster dressing is left on from one to three or five months. If the tendency to reluxation is slight the dressings are changed at short intervals; if the tendency to reluxate is marked the dressings are kept on longer. In favorable cases in young children a single dressing will suffice. In others the limb will have to be brought down gradually at each change of bandage. From three months to nine months or even longer may elapse before all retaining bandages are discarded. Lorenz has laid considerable stress on subsequent massage and gymnastics, but if the reposition and stability of the joint are good they are not especially needed, especially if the muscles have not been unduly injured by a preliminary (I believe unnecessary) mobilization.

If both hips are luxated, nearly all surgeons prefer to reduce them simultaneously instead of treating them one after the other. If the hips are operated on simultaneously the child is disabled on both sides and locomotion is practically impossible until the limbs are brought down at subequent dressings. If, however, only one has been operated on, then, if the cast is satisfactory, the child can go around on crutches or a high shoe in two or three days. In cases near the age limit preliminary weight extension in bed for two to four weeks with the leg in an abducted position may be tried.

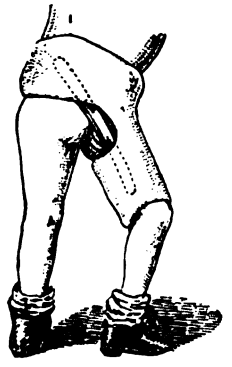


FIG. 1266.

In some instances, particularly in double luxations, difficulty may be experienced in bringing the limbs down parallel. When such is the case a strip of metal may be incorporated in the bandage running across from the inside of one thigh to that of the other just above the knees. This will tend to prevent abduction. If the plaster cast has been removed, Lorenz advises the use of an elastic band passing across from one knee to the other. To enable a patient with a one-sided luxation to go around, a high patten or shoe is used on the affected leg (Fig. 1268).

Double luxation cases can, as suggested by Lorenz, be given a small bench with rollers; by sitting astride it the child can propel itself along (Fig. 1269).

As pointed out by Gourdon, Kirmisson, and others, when the limb is placed in extreme abduction the head is not pointing correctly into the acetabulum, but is looking more forwards. Hence if this position is maintained too long the anterior part of the joint is weakened and an anterior transposition may result. For this reason it is best to change the position of the limb as soon as possible, without reluxation occurring, from the primary position of extreme abduction to one of moderate internal rotation, at the same time bringing

FIG. 1267.

the limb down a little or even to about 45°; the head then bores directly into the socket and is about perpendicular to the lateral pelvic plane. The greater the amount of anteversion of the head and neck that is present the greater is the amount of internal rotation necessary. In cases with extreme anteversion of the neck an osteotomy to correct it, as advised by Kirmisson, may be necessary, but that is very rare.

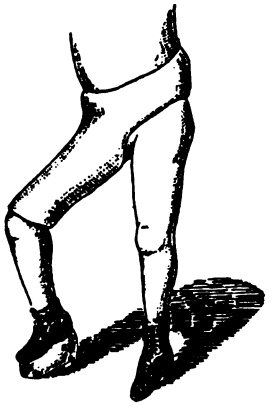


FIG. 1268.

Results.—It is practically impossible to give an accurate statement of results. What one operator calls a good result another will call bad; what one calls an eccentric replacement, another will call a reluxation. Le Damany has called attention to the unreliability of the statements of the mother as to the great improvement effected.

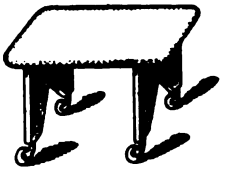


FIG. 1269.

Certain it is that with a judicious amount of suggestion on the part of the surgeon the parents at times may be persuaded to do and see almost anything. One fact, however, is evident and that is that the methods of replacement as well as of subsequent treatment as now generally employed have not changed materially since their general introduction.

Lorenz, at the Lisbon International Congress in 1906, stated that ideal

results were obtained in 50 per cent., and of the other 50 per cent. the greater part were transpositions below the anterior superior spine of the ilium.

Kirmisson at the same congress stated that in twenty-eight unilateral cases, two were found impossible of reduction and that good or even perfect results were obtained in eleven, or 39 per cent. Of twenty-four double cases only two had good permanent results. The results in double luxations are about one-half as good as in single luxations. Many operators claim more than 50 per cent. cures, especially in single luxations.

The fact remains that, according to Lorenz, and his statement is probably close to the truth, there are 50 per cent. more or less imperfect results.

He claims that in the transpositions or what he calls "lateral apposition," cases below and a little outside the anterior spine, while the limping is not improved the endurance is, and that they do not tend to luxate posteriorly.

We would like to agree with him in his view, but at present, at least, cannot. While the treatment undoubtedly does permanently benefit many of the cases, in others the condition seems to get worse rather than remain stationary until the cases can scarcely be distinguished from those who have had no treatment at all. In other words, we class transpositions under the head of failures, not total, it is true, but far from satisfactory. So distrustful of the results of the bloodless reposition is Sherman, of San Francisco, that he advocates replacement by open operation, not making a new acetabulum, but apposing cartilage to cartilage. His statistics are: In twenty-nine cases there were twelve functionally normal joints; eight anterior transpositions, one death and one ankylosis from infection. In twenty-seven cases followed by osteotomy he had 70.3 per cent. of normal function.

Personally, the difficulty experienced has not been in the reduction, but in maintaining the reduction. There seems to be little doubt that in some cases the acetabulum is so shallow as to absolutely fail to give proper fixation for the head of the femur.

When it becomes evident, after a thorough trial of fixation, that it is impossible to get a stable joint, then we believe that at present the best plan is to make an anterior incision and deepen the acetabulum.

Reduction by Open or Cutting Operation.—It is also to the Italians that the credit belongs of being the first to indicate the proper means to treat otherwise irreducible cases by operative means. Alfonzo Poggi, of Bologna ("Archivio di Ortopedia," 1888), on January 29, 1888, replaced the unresected head as nearly as possible in a newly scooped-out acetabulum by open incision. Many operations had been done before that time, but they were mainly on the muscles or resections of the head of the femur. Two years later Hoffa brought out his well-known method, and it is to him that the world is indebted for placing the operation on a firm basis and causing its worth to be generally recognized.

Hoffa at first used Langenbeck's incision which is a longitudinal one over the posterior portion of the joint. He also detached the muscles from the great trochanter. Later he made an incision beginning .5 cm. ($\frac{1}{5}$ inch) in front of the upper end of the anterior edge of the greater trochanter and prolonged downwards for 6 cm. ($2\frac{2}{5}$ inches) in front of the trochanter. Lorenz modified

Hoffa's operation by making his incision 6 to 7 cm. long wards from just behind the anterior superior spine to t It passed along the posterior border of the tensor fascia avoided the division of the muscles. The operation s called the Hoffa-Lorenz operation.

The Smith-Peterson incision gives an excellent expc This incision is made just below and parallel to the crest o point 4 to 5 inches posterior to the anterior superior spir it. From this point the incision is continued down on downward and slightly outward, for a distance of about the incision runs along the anterior edge of the tensor The fascia lata is cut along the entire incision, exposing fasiæ femoris muscles. The gluteal muscles are incise ilium, the tensor fasciæ femoris separated from the sartor by blunt dissection and the flap turned outward. The s and nerve lie in the flap and are not injured so there is li controlled. This incision exposes the capsule, the head and gives free access to the acetabulum.

The writer operates as follows: An incision (Fig. 127 long is made directly downwards from the anterior supe

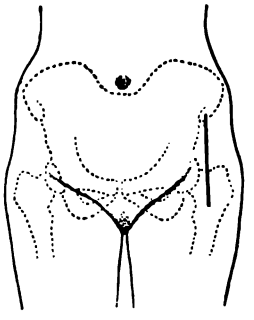


FIG. 1270.

lata is split and the sartorius anc inwards and the tensor fasciæ edges of the gluteus medius an wards. The separation of thes blunt dissection in the line of th the capsule of the joint and tl The capsule is freely opened duced downwards to determin traction of the capsule and the tabulum below. If any remna teres are present they are to be sule is almost invariably fou lumen contracted, especially in the older cases. An att dilate the capsule by introducing a Pryor dilator (Fig. 12 the constrictions and cutting away of the capsule to per head should be resorted to if necessary. The latter is us ure. If the acetabulum is sufficiently empty and well reduction can at once be made.

If the acetabulum is either filled with fibro-fatty ma to securely lodge the head of the femur, then it is to be c

This may be done with a wood carver's gouge, which its outer surface (Fig. 1272), or, what is not so good, w curette. To further smooth the cavity and even unde writer's rose burr (see Fig. 1273) will be found of service. on only half of its circumference in order to avoid wou femur. Attempts at reduction may now be made by of Paci or Lorenz. If these fail, then the writer's leve

may be tried. The small or large blade, which can be reversed for use on the opposite sides, is used according to the size and age of the patient. One end is hooked under the edge of the acetabulum while the other passes over the

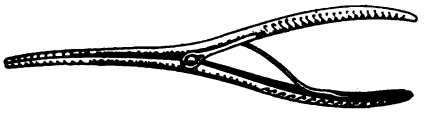


FIG. 1271.

FIG. 1272.

FIG. 1273.

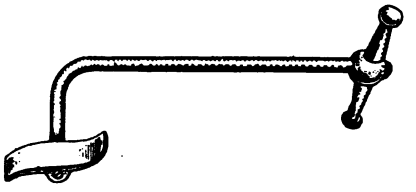


FIG. 1274.

head of the femur (Fig. 1275). By depressing the lever and abducting the femur the head can be made to enter the acetabulum. The most satisfactory method of reduction, however, is by direct traction on the limb. By utilizing the powerful traction obtainable with a Hawley or McKenna table the dislocated head can be readily drawn down to the acetabulum in young individuals, even in the older cases this method is quite successful. A distinct advantage in this proceedure is that your traction is continuously maintained while the fixation dressing is being applied and the danger of the head reluxating is lessened.

FIG. 1275.

In operating the greatest care is to be taken not to injure the cartilaginous covering of the head of the femur. Removal of the cartilage and exposure of the bare bone of both the head of the femur and acetabulum is liable to lead to anchylosis or restriction of motion. The limb is to be put up in plaster of Paris in a sufficiently abducted and extended position to prevent reluxation. The plaster may be removed every three or four weeks and passive motion made. It may be discarded in ten or twelve weeks. Should it be found to be absolutely impossible to replace the head in the [illegible]ulum, then a new one should be dug out of the side of the ili[illegible] the head placed therein. When this [illegible]cedure is carried out the [illegible]own of a bone flap from the (Albee)

aids materially in forming a good roof for the acetabulum and increases it's depth. Care should be taken to maintain powerful traction on the limb in the fixation dressing so that the flap may not be subjected to pressure and give way. This will give a stable support, but of course increases the shortening. Anchylosis is not likely to occur if the cartilage on the head of the femur is kept intact.

While the cutting operation is regarded unfavorably by many, the writer has found it to be very satisfactory. It must be admitted, however, that the operation is a difficult one and demands a skilled technic both from the standpoint of asepsis and reduction. It is the only thing that gives a fair promise of a stable and satisfactory result.

CHAPTER LXXXII

KNEE-JOINT

PUNCTURE. LAVAGE. INJECTIONS

Puncture of the knee is most commonly practised to withdraw serous effusions, recent blood extravasations, etc., and as a preliminary to lavage and the injection of various curative agents. The preparation of the patient, surgeon, assistants, and material must be as careful as if for an arthrectomy.

Step 1.—At the chosen point a little above and external to the patella inject a few drops of cocaine or analogous solution into the skin. With a tenotome puncture the skin. Through the puncture pass a trocar and cannula downwards and inwards in such a fashion that its point is made to touch the articular surface of the patella. This insures that the instrument has entered the joint.

Step 2.—Withdraw the stilette. Let the fluid escape. Clots of fibrin may plug the cannula; these may be removed by a probe. If nothing further is required, remove the instrument and apply a dressing which will exercise elastic pressure on the knee. If it is desired to practise lavage or injection, proceed to Step 3.

Step 3.—With an irrigator, or better, a common glass syringe connected with the cannula by sterile rubber tubing, fill the joint with salt solution or some mild antiseptic; disconnect the syringe from the cannula; permit the fluid to escape; repeat this washing as often as may seem necessary. If the disease is simple hydrops articuli many surgeons follow the lavage by injecting about three drams of 5 per cent. carbolized water. When tuberculosis is present one may inject the same quantity of a sterile emulsion of iodoform in glycerine (10 per cent. to 20 per cent.). J. B. Murphy uses the following emulsion: Iodoform, 10 per cent.; formalin, 2 per cent.; glycerine, q. s. In empyema of the knee Murphy, after puncture and lavage, injects a sufficiency of a 2 per cent. solution of formalin in glycerine to produce a mild amount of tension in the joint. He also uses this injection as a preliminary to most arthrotomies, as he believes the simple arthritis produced by it acts as an immunizing agent against infection during the major operation. In cases of traumatic dry arthritis Rovsing omits all lavage, notes that no fluid escapes through the cannula (if any turbid fluid escapes injection of vaseline is contraindicated) and then injects about 10 or 12 c.c. of sterile vaseline (see p. 980).

Step 4.—Withdraw the cannula. If necessary, close the puncture with a stitch. Apply dressings and a splint or light starch bandage. The usual practice is to keep the patient in bed for a few days and then permit him to go about with crutches. Willems advises strongly against the use of any splints and urges immediate and persistent *active* motion. This is good advice. The injection may be repeated in from two to six weeks. The treatment is not suitable when osteal lesions are present. If there is no marked improvement after two or three weeks, abandon the method.

Sclerogenic Injections (Lannelongue).—Nature seems to cure tuberculous foci by imprisoning them in an impenetrable capsule of fibrous tissue. Lannelongue has sought to stimulate nature to produce this capsule. His method is as follows: Cleanse the parts to be operated on. Charge an aseptic hypodermic syringe with a 10 per cent. solution of chloride of zinc. Inject 8 to 10 minims of this solution at each of various points around the diseased area. These injections must be made into healthy tissue, but immediately adjoining the disease. The irritating chloride of zinc is supposed to lead to the formation of scar tissue. Excellent results have been claimed, but the method has not become very popular. Mauclaire and Walther (Mem. et Bul. Soc. de Chir. de Paris, xlv, 1052, 1920) advocate the method in synovial tuberculous arthritis even when there are some osseous lesions. They warn against any pressure being exerted on the piston of the syringe during withdrawal of the needle for fear of injury to the skin. Broca saw Lannelongue's patients for several years and does not use the method.

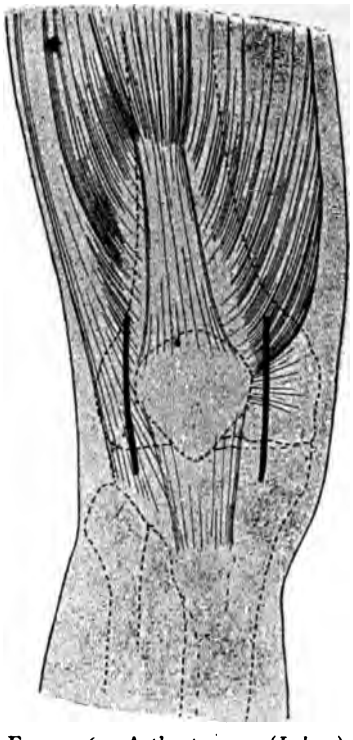


FIG. 1276.—Arthrotomy. (*Labey.*)

Arthrotomy Knee.—Arthrotomy may be performed for several purposes: (*a*) Exploratory; (*b*) for the removal of the fluids, *e.g.*, serous effusion, blood, pus; (*c*) as a preventive measure after infected or suspected wounds; (*d*) as a substitute for puncture and injection; here the wound must be closed after the selected remedial fluid has on the knee.

Murphy, whenever possible, prepare the joint by injecting glycerine-formalin solution a week or ten days before performing arthrotomy. Arthrotomy may be performd in several ways:

(A) Antero-lateral Incision.—For exploratory purposes or if serous or bloody fluid is alone present, make an incis on one finger's b[illegible]th external to the pa[illegible] from [illegible] edge of the [illegible]oint about two [illegible] This incision [illegible] the skin and cut

between the forceps so as to open the joint. Enlarge the wound in the synovialis with scissors so as to gain access to the upper pouch of the joint. Of course under certain circumstances a smaller incision suffices and should be made; for exploration and for many other purposes the larger cut described is essential.

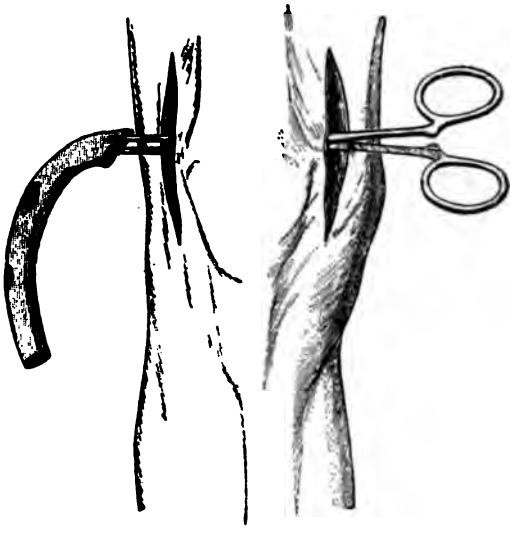


FIG. 1277.—Drainage knee. The tube must *not* enter the joint cavity, and if possible do not pass any instrument through the joint. (*Labey.*)

If pus is present or if the single incision is insufficient, make an identical cut on the opposite side of the patella (Fig. 1227). If drainage is required the wounds may be left open and loosely filled with gauze. Never permit any drainage tube or foreign body to penetrate the synovialis. *In draining a joint the tube ought merely to reach to the synovialis.*

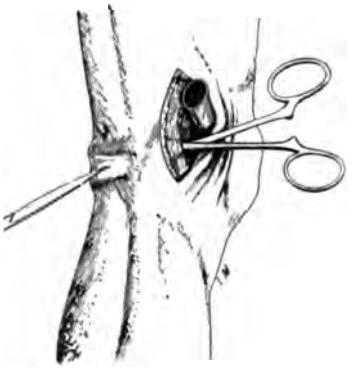


FIG. 1278.—Drainage knee. Counter opening being made. The tube shown should not penetrate the synovialis. (*Labey.*)

(B) The above incisions may not provide sufficient drainage for the joint cavity near the popliteal space, hence it may be necessary to supplement them by *postero-lateral* incisions on one or both sides. These are, under the circumstances, mere counter-openings. A postero-lateral counter-opening is conveniently made as follows: Pass a closed forceps through the antero-lateral wound (Fig. 1278), through the joint and make it raise up the soft parts on the outer side just anterior to the hamstrings, thus avoiding the external popliteal nerve; on the inner side it may go between the tendons. With a knife make a longitudinal cut so as to expose the forceps, seize the end of a rubber tube in the forceps and with it pull the tube down to but not into the wound in the synovialis. Do not permit any tube to be in the joint as it is certain to injure the synovialis disastrously. Postero-lateral incisions may and often are made as the primary incision, especially

in cases of pyarthrosis, as they by themselves give good access not only to the joint, but also to those popliteal bursæ which most commonly communicate with the joint. The operation is as follows:

(*a*) On the outer side.

Step 1.—Extend the knee. Palpate the tendon of the biceps. Make an incision about 2½ inches long, just in front of, and parallel to the tendon. This cut extends nearly down to the head of the fibula and divides the skin and fascia.

Step 2.—Slightly flex the knee so as to expose the anterior border of the biceps tendon. Retract the tendon backwards and expose the posterior border of the external condyle of the femur.

Step 3.—Open the capsule. Introduce the gloved finger into the joint and, guided by it, enlarge the opening as may be necessary.

(*b*) On the inner side.

Step 1.—The knee being extended, flex the thigh on the pelvis. This permits one to see and palpate a longitudinal groove beside and behind the internal condyle. The inner border of the groove is formed by the gracilis (coming from the pubis), the outer border by the semi-tendinosus coming from the ischium. Make a longitudinal incision in the above groove. The middle of the incision should be opposite the line of the knee-joint. Divide the skin and fascia. Expose the sartorius and half hidden by it, the gracilis. To the popliteal side of these tendons note the narrow tendon of the semi-tendinosus and more deeply situated the big semi-membranosus tendon. Retract these tendons forwards.

Step 2.—Open the joint on the posterior border of the internal condyle of the femur by an incision reaching from the border of the meniscus to the upper end of the capsule. If there is a serous bursa under the semi-membranosus, it is easily felt by the finger and opened. Instead of providing tubular drainage after postero-lateral incision, it has been advised to unite the posterior lip of the synovial wound to the skin by one or two catgut sutures. To obtain perfect drainage it has been recommended that the knee be kept flexed at an angle of at least 20 degrees. Willems' treatment (pp. 1030, 1031) is of the utmost importance.

(C) **Arthrotomy by Transverse Incision.—Dislocation Method.**—This operation may be performed in several ways:

(1) **Transverse Section of the Patella.**—Make an incision from one condyle of the femur to the other across the middle of the patella. Divide the patella transversely with a saw. With knife or scissors divide the lateral ligaments, etc., so as to open the joint to the full extent of the cutaneous wound. Strongly flex the knee and divide the crucial ligaments. Pull the upper fragment of the patella and the soft structures around it strongly upwards so as to expose fully the upper synovial pouch, to do this lateral incisions may be necessary. Pull the lower fragment of patella downwards so as to expose the lower articular pouches. Keep the knee flexed to such an extent that the whole popliteal surface of the joint is exposed but no injurious compression is exerted on the popliteal vessels. After cleaning the joint cavity and swabbing with Harrington's solution or its equivalent fill it *loosely* with gauze and apply abundant

the skin of the thigh. The rest of the operation is the same as that already ribed. After recovery from the infective process has taken place, Peck others recommend performing arthrectomy, arguing that even if it was ible to obtain closure of the wound without removing the articular surfaces, there would be no chance of getting a useful joint and there would be a

FIG. 1280.—Drainage knee. (*Peck.*)

ability of fibrous anchylosis with subluxation of the tibia on the femur. ne author it seems wise not to adopt any hard and fast rule; if reduction and tion of the articular surfaces in proper position is easy then endeavor to n a more or less mobile joint, if this fail it is easy to resect at a later date.

emarks on Arthrotomy.—(The general principles here enunciated apply lly to other joints.)

or exploratory purposes unilateral or bilateral incisions are commonly ient though for many purposes in the absence of infection Robert Jones'

median section of the patella is of extraordinary value. The preliminary injection of Formalin-Glycerine urged by J. B. Murphy is unnecessary as the synovialis is really resistant to infection. When the exploration is completed, close the wound in the synovialis with accuracy and then suture the more superficial structures. To avoid possible anchylosis, Willems insists on *active* and persistent motion of the joint to be begun as soon as the patient comes out of the anesthetic. After the operative removal of blood and serous fluid the same remarks apply. If fluid reaccumulates in the closed joint it ought to be aspirated. The principle of active mobilization after non-infected lesions of joints was urged many years ago by the late Wharton Hood of London in his entrancingly practical book 'The Treatment of Injuries' (MacMillan and Co.). All wounds of joints ought, if possible, to be converted into clean closed lesions and treated on the above principles.

Wounds of Joints.—Remember the essential distinction between contamination and infection. All wounds of joints must be considered contaminated. It takes a varying time for the contaminating infective material to multiply and penetrate the tissues. It commonly takes from twenty-four to forty-eight hours before a septic arthritis develops (Pierre Duval, Surg., Gyn. and Obst., Sept., 1919).

In every wound the damaged skin should be removed. In many cases of through and through machine gun wounds this suffices. In most cases the whole track of the wound must be excised cleanly with, of course removal of all foreign bodies, etc.

When the joint cavity is reached freshly sterilized instruments and gloves should be used. (In severe joint lesions Duval begins with arthrotomy and does the wound excision later in the same sitting.) If there is no great intra-articular injury, trim and suture the synovial wound with meticulous care. Close the more superficial wound with, if thought necessary, a silkworm gut drain down to but *not* through the synovial wound.

If there is much destruction of the soft parts and it is therefore impossible to close the wound after 'debridement' a strong endeavor must be made to close the synovial cavity, if necessary, by mobilization of the neighboring synovialis such as the supra-patellar pouch.

Active mobilization should be begun at once. In the knee in the absence of damage to the bone *very* early walking is a valuable means of treatment. The use of antiseptics has been given up when operation can be performed early. During 1914 and 1915 the mortality of knee joint wounds was 27.0 per cent. and there were 30 per cent. amputations. During 1916, 1917 and 1918 the mortality was 0.9 per cent. and amputations were done in 2.9 per cent. of the cases. The improvement was due to early operation and avoidance of intra-articular drainage.

When there is injury to the bone the lines of fracture must be cleaned, with the chisel if necessary, and all parts must be retained to as great an extent as possible. When the bone injuries are lateral and at the same time extra-articular or intra-articular, by proper suture of the synovialis the cavity is separated from the joint. Bone cavities when well cleaned can be [illegible] the joint, may be plugged with bone wax or by a pedunculated [illegible]

Fissures of the bone should be opened by a lever and lightly pared. Nails or screws may be used when necessary to keep fragments in proper line. As far as possible a normal joint outline must be preserved. When this is done the joint is to be treated almost exactly as when there has been no bone injury. If active mobilization causes displacement of large bone fragments, it is contra-indicated, hence part of the necessity for fixation of such fragments. Division of the patellar ligament provided that it has been well sutured does not necessarily interfere with active mobilization. Excision of an injured joint is rarely necessary except when the traumatism has practically performed that operation.

Purulent Arthritis.—In all cases of purulent arthritis it is notoriously difficult to provide efficient drainage. Apart from extremely extensive operations which inevitably cause anchylosis the only thorough drainage is obtained by means of *active* motion during which the pus is squeezed out of the joint. Willems (Surg., Gyn. and Obst., June, 1919) performs lateral or bilateral arthrotomy as early as possible. In the knee the incisions extend from above the supra-patellar (subfemoral) bursa down to below the articular interline. As soon as the patient awakens from anesthesia, *active* movements are begun and are kept up at frequent intervals in spite of pain, the feeling of weight in the limb, etc. Active motion is necessary to express the pus. Pain especially posteriorly is a sign that there has been too little motion. If the Willems' method is thoroughly carried out recovery should ensue in about two months without anchylosis even when there is some slight osseous lesion. When there is a grave intra-articular bone lesion the results are much less certain.

Irrigation of the joint is unnecessary and may be harmful. As suppuration lessens, progressively close the arthrotomy wound only leaving such opening as is strictly necessary for the escape of the pus which is still forming. The patient should walk early before the wound is healed, this helps to expel the pus. Willems writes "preservation of the articular mobility seems due to the fact that the perfect drainage limits infection to the synovia alone and prevents its propagation to the cartilage and bone."

Arthrotomy for the Removal of Loose Bodies.—Several varieties of organic bodies may lie loose in the joint and cause very distressing and crippling symptoms. The bodies may be single or multiple, may be absolutely free or be pedunculated. The bodies may occupy almost any part of the cavity, but only give rise to symptoms when nipped between the articular surfaces. They may be very movable and hence are liable to get out of reach. The patient by making certain movements can often bring the body into a superficial position. If the body is very mobile it is sometimes wise, after thorough cleansing of the parts, to harpoon and so fix it with a sterile needle. It is then easy to cut down on to the body under a local anesthetic and remove it *without* introducing a finger into the wound.

Usually a general anesthetic will be required and a larger incision made in order to explore the cavity with a gloved finger. The operation is essentially that of antero-lateral arthrotomy. When a delicate pedicle is present it is easily ruptured; a stronger pedicle may require a snip of the scissors. The wound is closed by two layers of sutures without drainage.

[redacted]odies can often be demonstrated by the X-rays, but a warning is

FIG. 1281.

FIG. 1282.—(*Freeman.*)

here necessary. In the gastrocnemei muscles there are often present smal sesamoid bones (Fig. 1281), which may be mistaken for loose bodies in the joint.

Displaced Semilunar Cartilage. Internal Derangement of the Knee-joint (Hey).—Many methods have been devised for exposing a displaced semilunar cartilage. Annandale in 1885 described a method of anchoring the cartilage through a simple transverse incision.

Freeman reflects a U-shaped flap of all the tissues, including the capsule, upon the internal or external surface of the joint, as required, and lying between the lateral ligament, on one hand, and the patella and its ligament on the other (Fig. 1282).

The base of the flap may either be upwards or downwards but it must be so placed as to freely expose the upper edge of the tibia and the semilunar cartilage.

It is now easy, in suitable cases, to reduce the cartilage and fix its edge to the periosteum by a few stitches. This treatment is now practically discarded in favor of excision which gives as good results and more insurance against recurrence. When the cartilage is exposed seize it with a strong hemostatic forceps or pull it outwards with a blunt hook. Cut it from its moorings with scissors or twist it until it tears free. Close the wound in the capsule and fascia with fine catgut. Close the skin wound. Dress. Apply a posterior splint or a starch bandage. Begin gentle motion in about two weeks. Gradually increase motion. Massage is useful. A number of weeks may pass before absolutely free and comfortable motion is possible.

Jones' Operation.—Robert Jones ("Annals Surgery," Dec., 1909) describes his method of operating as follows: "For some time I have given over operating with the knee in such a position that it has to be further flexed during the proceedings. Unless the greatest care is taken, the clothes get shifted or air is introduced into the joint. All surgeons of experience will have noted this. To avoid this risk I begin the operation with the patient's knee hanging at right angles over the foot of the table (Figs. 1283, 1284). To shift during the operation is to change the plane of the incision. The final cleaning of the knee takes place while the joint is flexed and the skin tense. Some thicknesses of sterile gauze squeezed out of 1 to 1000 biniodide of mercury is wrapped round the joint and the incision is made through the gauze, the cut edges of which are fixed to the wound. The length of incision which practically always suffices is three inches, the incision into the capsule is much smaller (Fig. 1283). Long skin incisions obviously add to the risks, and are only very exceptionally needed. The incision should be slightly curved and extend from an inch within the lower angle of the patella to half an inch below the tibial margin, curving more acutely at this point towards the lateral ligament. The interior of the joint is then inspected with the aid of carefully applied retractors. No less authorities than Sir William Bennett and Mr. Whitelocke advocate entering the finger for exploratory purposes. The finger should never enter the joint. Neither the surgeon nor the assistant should touch the wound with anything but sterile instruments. The sutures for the capsule should be handed on forceps and I usually make the stitches a blanket-stitch. In the flexed position, the best [redacted] the interior of the joint and the cartilage can be well inspected. [redacted] and hides the view, draw it outwards with a skeleton

ractical suggestion. Never pull upon the cartilage nor cut when pulling; ches more, and to my knowledge is a cause of recurrence.
te the degree of detachment and go a short distance further with a tting the cartilage clean across, and then complete the incision along r border. Having removed the cartilage, look for fringes, tabs or ssible agencies which may cause trouble in the future, and remove Stitching the cartilage should be an obsolete operation. If the cartilage slightly mobile and the history characteristic, it should be removed h. During the operation, dabs taken directly from the sterile drum over the wound during any interval, and no dab should be used which exposed to the air.
ver tie vessels, always use a tourniquet until the dressings are bandaged, r drain. I used to drain, years ago, but I consider it quite unneces- l an additional communication between skin and joint. The synovial ne capsule and skin should be separately sutured and the sutures should through the whole thickness of the skin. I now know no anxious , the skin never reddens, nor do I have trouble with effusion.
stitches are left in position for eight days, the knee kept slightly bent nt for the same period, or a few days longer, and then passive move- nd massage are started. Special attention should be paid to the weak ps and in from three to four weeks normal exercise should be allowed."
rt Jones' median longitudinal section of the patella gives remarkably ess to the knee for the removal of any misplaced cartilages as well as ation upon the tibial spines for which it was devised.
n ought we to operate for displaced semilunar cartilage?
ought *never* to operate before giving conservative means a fair and d trial. Hence acute cases are not for operation. Cases without can generally be kept comfortable or cured by the use of some hinged s to the knee or even by raising the inner side of the heel of the shoe make the patient walk in a pigeon-toed fashion. When effusion is (not acute synovitis) or when there is crackling on motion, operate. sion means constant irritation and injury to the synovialis, the crack- erally means that the cartilage has become rolled upwards and joint- re or less like a pea.
e "British Med. Journ.," Dec. 9, 1905, Mr. A. E. Barker describes some forms of internal derangements of the knee. The symptoms and n these cases are identical with the classical lesion. The pain and ss are on the inner and anterior aspect of the head of the tibia. After the joint by a curved internal antero-lateral incision Barker found the normal, but when the knee was flexed and the tibia rotated outwards hite "tag" of dense fibrous tissue was seen projecting backwards from tissue behind the patella. On the removal of the tag, cure resulted.
r similar circumstances after the same incision Barker found no dis- nt of the internal cartilage, no retropatellar "tags," but beyond the igament he saw a white mass which he pulled forwards with a hook d it to be the *external* cartilage attached at both ends but torn from nary ligament by an injury sustained forty-four years before. Re-

member that flexion and external rotation of the knee after it is opened may reveal the cause of disabling symptoms and permit of cure. Remember that the synovialis of a healthy joint only feebly resists infection and hence that the ungloved finger must never touch a wound made in a joint.

Repair of Ruptured Crucial Ligaments.—Mayo Robson operated on a man for lameness resulting from a severe accident sustained nine months previously ("Clinical Society," London, Nov. 28, 1902). Battle operated on a case in similar fashion. "On admission, the right knee was swollen but free from tenderness. When the muscles were pressed the bones were in good position, but as soon as the muscles were relaxed the tibia fell backwards until stopped by the ligamentum patellæ, and on manipulation the head of the tibia could be brought forwards in front of the femur, there being also free lateral movement of the head of the tibia on the femur and some fluid in the joint. Not only were all the ligaments relaxed, but the crucial ligaments had been ruptured. On November 21, 1895, the joint was opened by a semilunar incision carried across the front and dividing the ligamentum patellæ. The synovial membrane was found inflamed, and there was excess of fluid in the joint. Both crucial ligaments were completely ruptured, having been torn from their upper attachments, the ends being in a shreddy condition. They were stitched in position by means of catgut ligatures and the anterior being stitched to the synovial membrane and tissues on the inner side of the external condyle, and the posterior, which was too short and was split in order to lengthen it, was fixed by sutures to the synovial membrane and cartilage on the outer side of the inner condyle. The wound was then stitched up by means of buried catgut sutures, and was closed superficially by interrupted silkworm-gut sutures. Complete restoration of the normal movements of the joint occured. The stitches were removed on December 4, and on the fourteenth plaster of Paris was applied, and he was allowed to get about on a Thomas, splint and to go home. The plaster was removed in a month, after which movement gradually returned under massage. When seen on October 24, 1901, the patient was walking without a limp and could run. He said that his leg was perfectly strong, and that he could work eight hours a day at his old employment of getting coal, and that he had never been off a day on account of his knee since the year of his accident. The joint could be extended to the straight line and flexed just beyond the right angle, there being no abnormal lateral or antero-posterior mobility whatever."

Pringle has had two cases of injury to the knee in which abduction while the knee was extended was a prominent symptom. In both cases the provisional diagnosis was ruptured internal lateral ligament. On opening the knee of one of these cases the anterior crucial ligament, still attached to its bony insertion, was found to be torn off the tibia, taking the tibial spine with it. Pringle sutured the spine in place and obtained a good result. In the second case, after opening the knee, the anterior crucial ligament was found torn from its femoral attachment and was then sutured by Pringle to the tissues on the median side of the external condyle ("Annals of Surgery," Aug., 1907).

W. J. Frick repaired the ruptured anterior crucial ligament in two cases, one of his patients was a professional base-ball player who was able to resume his work within six months of the operation.

Robert Jones' Operation (R. Jones and S. Alwyn Smith, Brit. Journ., Surg., i, 89) is designed for treatment of fractures of the tibial spine "when full extension is not possible and disability exists in addition, whether it be pain stiffness or effusion." Flex the knee over the table at almost a right angle. Make a vertical median incision from one inch above the patella down to the tubercle of the tibia. Saw the patella longitudinally and split its tendon. Separate the segments of the patella to the border of the condyles. Remove the fat from behind the patella and so gain a good view of the spine and of the anterior crucial ligament. Remove any obstructive mass. Straighten the knee. Suture the ligamentum patellæ, the aponeurosis and the quadriceps tendon. Do *not* wire the bone.

E. M. Corner (Trans. Surg. Sect. A. M. A., 1914) is an enthusiastic advocate of the Robert Jones method of opening the knee. To gain free access he splits the quadriceps upwards as far as may be necessary. He lays great stress on the importance of careful suture of the synovialis with fine catgut to prevent blood entering the knee as hemarthros is very favorable to infection. After operation no splint is necessary though its use for twenty-four hours may be of value. The patient remains in bed for three weeks. Active motion does not need to be preceded by passive motion.

Through the Jones' incision Corner operates on displaced semilunar cartilages; ruptured or stretched crucial ligaments; fractures of the tibial spines; various fractures of the femur, etc. He urges that the synovialis covering the fat below the patella be left intact if possible or, if divided, that it be carefully sutured.

Operation for Stretched or Loose Crucial Ligaments (Corner).—The anterior ligament is almost invariably affected. Bore a hole through the external condyle and through the loose ligament. Thread a *non*-absorbable suture on the dri l and pull one end of it through the condyle. Pass the other end of the suture around the ligament and pull it through a second hole bored in the external condyle. When the suture is tightened and tied the relaxed ligament is tightened and reefed.

If the posterior crucial ligament is at fault the suture would be passed through the internal condyle. The knee ought to be a little flexed when the suture is tied.

Operation for Fracture of Tibial Spine.—In spite of the advice of Robert Jones, Corner advocates fixing the fragment of spine by a catgut suture passed twice through the tibia in the same way as is done through the femur in reefing the crucial ligament.

Operation for Ruptured Crucial Ligament.—When the ligament is so injured that its repair is impossible and when it is causing much disability Corner passes a **U** suture of wire through two perforations in the external condyle and loops it through a similar wire suture which perforates the tibia (Fig. 1285). The value of this operation is very doubtful.

Operation for "Internal Derangement of the Knee".—Robert Jones' median incision is recommended by Corner in the treatment of displaced semilunar cartilages and for loose cartilages even when they seem single and easily excised through a small incision directly over them, the reason for this being that other

remediable lesions are so often present which would be overlooked and cause si sequent chagrin if the smaller incision had been selected.

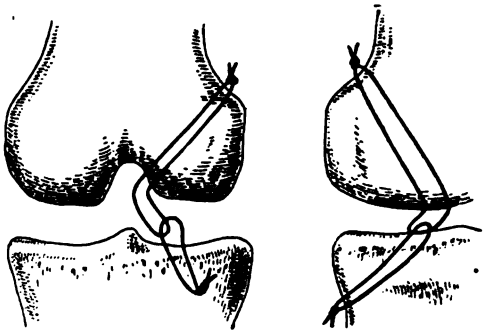


FIG. 1285.

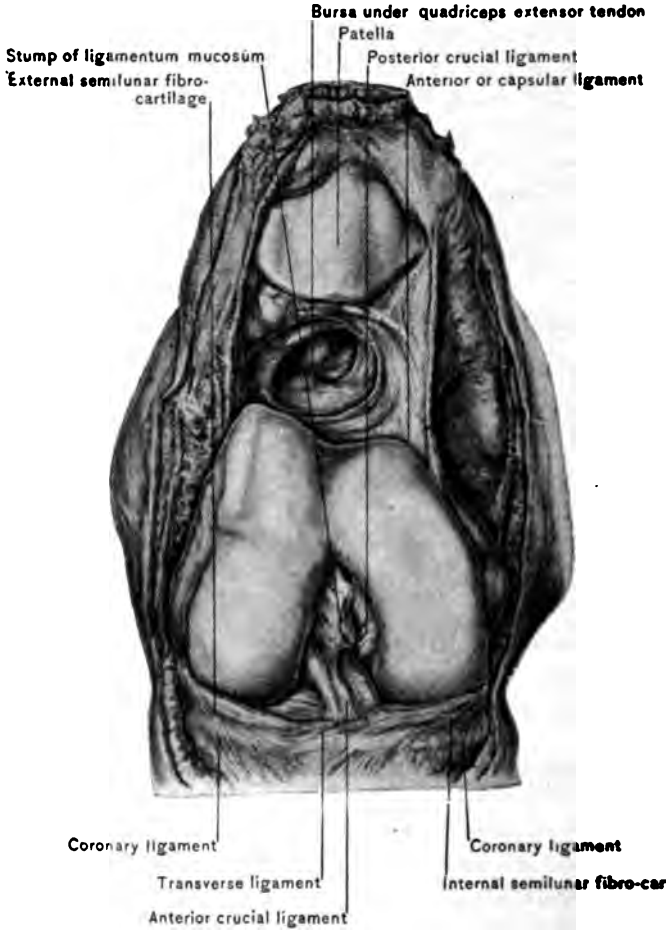


FIG. 1286.—(*Deaver.*)

Figure 1286 will remind the reader of the anatomy of the knee. Figure 1287 shows fracture of the tibial spine in which the

enderness, swelling and undue lateral mobility. Hayden treated the case nobilizing with plaster of Paris and obtained a perfect result about 79 days he injury was received.

pair of Ruptured Lateral Ligaments.—When the lateral ligaments of the re ruptured they may be exposed and sutured but earlier use and better n and strength may be expected from the following procedure reported by ter ("Archiv f. klin. Chir.," xcviii, 819). Expose the injured parts by a cision. Suture any wound of the joint capsule. From the tendon of the femoris obtain a non-pedunculated (unattached) flap of suitable length

FIG. 1287.—(*Hayden.*)

nickness. Suture the flap to the femur above and the tibia below. If uturing of the flap to the periosteum seems insecure, reflect a flap of perios- cut a groove in the bone, place the end of the flap into the groove, fix it with a staple and cover with the periosteal flap.

hrectomy.—Excision.—The term arthrectomy is here used as meaning noval of synovialis either alone or plus excision of the diseased portions of ge and bone. The term excision is reserved for operations where the whole ar surfaces are formally excised.

ethod A.—Lateral Incision.—*Step* 1.—Beginning at the inner side of the ntum patellae, make a curved incision upwards and backwards to the r margin of the internal lateral ligament where it crosses the line of the ation; continue the cut upwards over the internal epicondyle and make it forwards and upwards around the inner and upper part of the superior

synovial pouch (Fig. 1288). Beginning at the outer side of the insertion of the ligamentum patellæ, make a corresponding incision on the outer side of the joint. Both these incisions penetrate at once to the bone in the lower part of the incision, while in the upper part the vasti are divided and articular capsule is exposed.

Step 2.—**Synovialectomy.**—With sharp retractors elevate the anterior edge of the wound (on the outer side) from the capsule. With forceps, knife, and scissors dissect the anterior part of the diseased capsule from the soft parts covering it, until the patella or the middle line (Fig. 1289) is reached. Separate the upper synovial pouch from all its surroundings. Divide the synovialis where it is inserted into the patella. Make a similar dissection through the internal wound and remove the separated synovialis. Dislocate the patella outwards in such a manner as to expose its under surface and that of the quadriceps and the patellar tendons. Inspect these structures and remove from them any shreds of synovialis which may have been left. If it is necessary to remove the synovialis from the popliteal side of the joint, make a *partial* division of the internal lateral ligament and, if necessary, of the tendo patellæ. Dislocate the joint so as to make the articular surface of the femur (or tibia) protrude through the inner wound. To obtain complete exposure it is necessary to divide the crucial ligaments. With great care dissect away the synovialis from the popliteal surface.

FIG. 1288.—Arthrectomy. Lateral incision.

This completes the synovialectomy. If no more disease requires removal, cleanse the wound. In tuberculous cases it is wise to rub the wound with iodoform powder. If possible unite the crucial ligaments with catgut sutures. Repair the lateral ligament and patellar tendon. Close the wound with or without drainage.

Step 3.—(*a*) Bony anchylosis is desired though no bone is diseased. With a strong knife or with a chisel pare away the articular cartilage from the femur, tibia, and patella, removing also the remnants of the crucial ligaments and the semilunar cartilages. Close the wound and treat as a fracture.

(*b*) Foci of disease are found in the bones to a limited extent. The most common lesions are foci of tuberculous granulation-tissue infiltrating and absorbing the bone, and necrotic foci. If the active advance of the disease has ceased, the diseased foci will be found surrounded by a mass of sclerosed bone—a favorable sign. With a sharp spoon or a gouge remove all the diseased tissue. Necrotic foci are often so intimately attached to the surrounding bone that they require removal by means of chisel and mallet. After removal of the disease swab the osseous wound with tincture of iodine or rub in iodoform powder or fill the cavity wth Mosetig's bone plug. Close the wound with or without drainage and treat as a fracture.

Step 4.—**Excision or Resection of the Joint.**—Synovialectomy or excision of local osseous foci of disease is inadequate: it is necessary to remove the

ticular ends of the bone. Flex the hip. Make the lower end of the femur otrude through the wound (Fig. 1290). Apply a saw at right angles to the

FIG. 1289.—Arthrectomy through lateral incision.

FIG. 1290.—Arthrectomy through lateral incision.

mur and saw off the articular end of the bone. Be careful as to the line of ction, so that when the sawn surfaces of the femur and tibia are approxiated the patient may have a straight or very slightly flexed knee without

genu valgum. Riedel ("Zent. für Chir.," 1912, No. 28), before applying the s extends the knee into the natural straight position and then saws *partia* through both the tibia and fibula. With the limb in this position it is m easier to divide the bones in the correct lines. After partial division of the bo flex the knee and complete the bone section. With forceps or saw remove posterior sharp edge of the raw surface of the femur. Unless this is done sharp edge of bone may do harm and between the remnants of the epicondy a dead space is left which may interfere with healing (Riedel). Still keeping thigh flexed, push the articular end of the tibia upwards so as to be clea the soft parts, especially those of the popliteal space. Saw a thin slice from tibia, keeping the saw parallel to the articular surface. With forceps trim sharp edges of the bone. When removing the lower e of the femur in young people, be careful to locate a avoid the epiphyseal line. To bring this line into vi it may be necessary to shave away a thin slice from t side of the inner or outer condyle. Examine the r surfaces of the bone. If disease is found remove it wi the sharp spoon or chisel. Review the whole wou territory and remove any remnants of disease, clea preferably by dissection, all fistulous tracts. Close t wound with or without drainage. Treat as a fractur Voluminous dressings are necessary. Apply a lo posterior splint. Put the patient in bed with the lim elevated to an almost vertical position. This positio is retained for at least twenty-four hours.

FIG. 1291.—Volkmann's incision.

The other methods of arthrectomy and excison ma be treated shortly as they differ from the above mostl in the manner in which the joint cavity is exposed.

Method A has been described very fully merely as matter of convenience not because of superiority ov the other procedures about to be considered.

Method B.—Volkmann's Transverse Incision. From one epicondyle to the other make an incisi which passes over the middle of the patella (Fig. 1291). The cut is made the bone throughout its whole course, and opens the joint. Saw through t patella transversely. With sharp retractors pull the lower fragment of t patella forwards and downwards, thus exposing the synovialis lining the terior wall of the lower pouch of the joint. With forceps, scissors and kn dissect the above-mentioned portion of synovialis from its connections u the semilunar cartilages are reached. Remove the semilunar cartilages a synovialis together. Divide the lateral and crucial ligaments. Flex the k until the back of the calf lies in contact with the thigh and pull the leg do wards. By this manœuvre the joint is made to gape widely and the poste portion of the capsule, viz., that opposite the popliteal space, is made fre accessible (Fig. 1292). Dissect away the posterior synovialis. Remember location of the popliteal vessels and nerves.

With sharp retractors pull the upper fragment of the patella forwards a

wards and dissect away the synovialis of the upper pouch in the same manner was done with the lower. The deep fascia of the thigh may prevent the cessary elevation of the flap containing the patella; if this is so make a longi-dinal incision through the fascia on each side of the patella, without cutting e skin.

FIG. 1292.—Arthrectomy.

Excise the articular ends of the bones as already described. When closing e wound it is necessary to unite the divided patella by means of sutures, preferably of catgut (chromicized or iodized).

Method C.—Make a **U**-shaped incision from one epicondyle to the other, e convexity of the incision corresponding to the insertion of the ligamentum tellæ. The incision only involves the skin and subcutaneous tissues. Reflect e **U**-shaped skin flap upwards. This exposes the patella and part of the capsule of the joint. Make a transverse incision through the fascia covering the tella. Bisect the patella transversely with a saw. Divide the articular psule on each side of the patella. Proceed as in Method B.

Method D.—This method is the same as C except that the convexity of the n flap is upwards.

Method E.—Beginning at the posterior part of one femoral condyle make urved incision which ends at a corresponding point on the other side of the ee. The lowest point reached by the curved incision is in the middle line the insertion of the ligamentum patellæ. The cut reaches to the bone roughout its whole length. The flap thus outlined contains the patella and

[illegible]

[illegible]

[illegible]

closing the wound without drainage. At the same time treat the joint conservatively. Secondary (pyogenic) infection calls for radical treatment.

If the functions of a joint are irreparably lost the sooner excision of the tuberculous synovial membrane and other diseased parts is performed, the better. "The best test of the amount of damage done to the joint is the extent of its mobility under an anæsthetic. A creaking stiff joint with only slight mobility under anesthesia should be excised" (Morison).

Any method of operating is good which fills the following requirements: Free access to the joint. Ready removal of all diseased tissues, with the minimum destruction of healthy structures, and the reconstruction of a sturdy useful limb with an anchylosed knee and as little shortening as possible.

Operation is far more rarely indicated in children than in adults. In adults belonging to the poorer classes operation may be required to save time and expense, although the disease might well be considered curable by conservative means.

Absolutely typical excisions are rarely proper. The true surgeon, in suitable cases, explores, removes the disease, and repairs the parts in the manner best calculated to give a useful limb.

At present anchylosis is almost always to be sought for, but the work of Murphy and others on the interposition of fat, etc., between the joint surfaces, leads to the hope that even after excision of the knee for tuberculosis a good movable joint may be obtained.

Arthritis Deformans.—W. Müller ("Archiv für klin. Chir., xlvii, H. 1) advocates operative interference in certain cases of arthritis deformans and reports good results. The operation consists in exposing the articular cavity by lateral incisions, excising all the diseased synovialis, extracting all foreign bodies and with a chisel shaving off all bony excrescences. The capsular and skin wounds are separately closed with sutures, drainage provided, immovable dressings applied and rest maintained. Passive motion is begun as early as the third week. The after-treatment consists of massage and of movements (sometimes under anesthesia) patiently carried out. Active motion is begun as early as possible.

Rutherford Morison has in two cases obtained good results by excising the joint.

In cases of "Creaking knees" with effusion Robert Jones opens the joint, removes all fringes present and closes the wound; if no effusion is present he does not operate.

In general terms it may be said that in arthritis deformans if there is much pain and disability, if conservative treatment has failed to give relief, arthrotomy is indicated for exploration, to be followed by some form of atypical resection according to the lesions found.

Congenital Dislocation of the Knee.—Hübscher's Operation.— Hübscher (von Salis, "Deutsche Zeitschrift für Chir.," cxiv, 148) operated on a case of anterior dislocation of the tibia on the femur in a girl fourteen months of age. The patella was absent. Manual reduction was impossible. The skin was reflected in a flap from in front of the knee (Fig. 1293). The tendo patellæ was found to be short and to constitute an impediment to reduction. The

tendon was incised longitudinally down to its insertion into the tibia (Fig. 1294). A portion of the tibia corresponding to the insertion of one-half of the tendo patellæ was separated from the rest of the bone. The other half of the tendon was divided transversely high up. Only after division of the anterior capsule

FIG. 1293.

FIG. 1294.

FIG. 1295.

FIGS. 1293, 1294, AND 1295.—Hübscher's operation. (*Hübscher.*)

of the knee was complete reduction possible. The two halves of the patellar ligament were united in such a manner that the fragment of tibia attached to one of them lay in the normal position of a patella (Fig. 1295). The wound was closed. The knee was immobilized in a position of slight flexion. The result was good.

CHAPTER LXXXIII

PATELLA. TUBERCULOSIS

In cases of primary tuberculosis of the patella when the focus of disease is small Murphy advises the removal of the diseased focus, the filling of the resulting cavity with Mosetig's iodoform plug or with his own glycero-gelatin-formalin plug. [Murphy's plug is made as follows: Boil 100 c.c. white gelatin in 150 c.c. glycerine and 500 c.c. water. Add 1 to 2 per cent. of formalin.] In advanced cases which do not involve the whole patella preserve the cartilage between the patella and the joint for fear of infecting the joint. The cases suitable for the above treatment are rare and more rarely still, will a sufficiently accurate diagnosis be made, as the operation should be carried out without direct inspection of the joint cavity.

When the patella is irreparably diseased, but the knee-joint has escaped tuberculous involvement, excision of the patella is proper. In such cases the knee will have suffered from acute synovitis, due to the proximity of the tuberculous foci.

Murphy's Method of Excising the Patella.—Preliminary Treatment.—Before almost all operations on the knee-joint (fractures of patella, cartilages, etc.). Murphy produces a chemical or simple arthri[illegible]

FIG. 1296.—Excision of patella. (*Murphy.*)

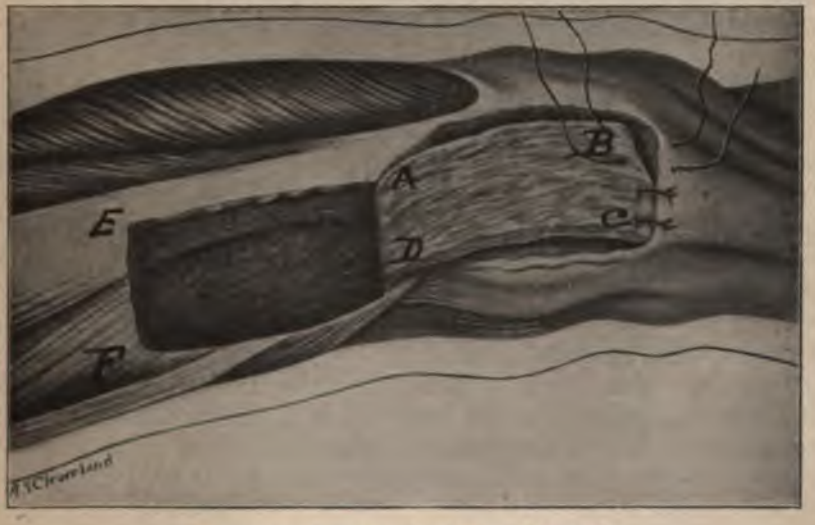


FIG. 1297.—Excision of patella. (*Murphy.*)

operates after the patient has recovered from this. He believes that the *cured* arthritis produces a local immunity to infection and traumatic irritation. If this idea is correct, and Murphy has a habit of being correct, the preliminary treatment is important.

Twenty-four hours *prior* to use, prepare a 2 to 5 per cent, solution of formalin in glycerine. Inject 2 to 6 drams of the solution into the joint a week or ten days before operation.

The Operation.—*Step* 1.—Open the knee-joint by a 7-inch incision on the outer side of the patella (Fig. 1296), ("Surg., Gyn., Obst.," March, 1908, p. 260).

Step 2.—Make a subaponeurotic excision of the patella, leaving the cut ends of the quadriceps tendon and tendo patellæ exposed.

FIG 1298.—Excision of patella. (*Murphy.*)

Step 3.—Reflect downwards a flap (A B C D) (Fig. 1297) consisting of portions of the quadriceps tendon and vastus externus muscle. The flap must be long enough to easily reach the cut end of the tendo patellæ. Stitch the end B C of the flap to the ligamentum patellæ either in the end-to-end or overlapping fashion. Close with sutures the defect A E F D.

Step 4.—Suture the aponeurosis of the patella securely to the divided edge of the flap (Fig. 1298).

Step 5.—Close the skin wound, after providing for drainage. Apply dressings and a straight posterior splint.

It was shown long ago by Wharton Hood that the patella is by no means essential to good function of the knee, hence the above operation does not produce so much disability as might be suspected.

CHAPTER LXXXIV

OSTEOTOMY FOR BONY ANCHYLOSIS OF THE KNEE

When tuberculosis is the cause of the bony anchylosis it is wise to operate as far as possible from the joint lest encapsulated infective agents be let loose. Operation is indicated when malposition interferes seriously with walking or standing. Whichever method of operating on the anchylosed bones is chosen, contracture of the ham-string muscles may interfere with correction. Under such circumstances tenotomy, tendon lengthening, or perhaps transplantation of the ham-strings into the quadriceps tendon becomes necessary.

Rhea Barton (1835) was the first to perform open, and Langenbeck (1852) to perform subcutaneous osteotomy for knee anchylosis. Gurdon Buck excised an anchylosed knee (essentially a cuneiform osteotomy) in 1844.

I. **Linear Osteotomy of the Femur.**—On either the inner or outer side of the rectus tendon "on a level with a line drawn transversely, a finger's breadth above the upper portion of the external condyle," make a longitudinal wound sufficient to admit a Macewen osteotome. Proceed exactly as in supra-condyloid osteotomy. Figures 1299 and 1300 show the result of this section.

II. **Linear Osteotomy of Both Femur and Tibia.**—This operation is suitable in cases where section of the femur alone is insufficient. Divide the femur as described in the preceding paragraphs. Divide the tibia immediately below the anterior tubercle (see p. 971). Figure 1301 shows the result of the double section. Instead of making a linear osteotomy of the tibia Werndorff ("Wiener med. Woch.," lix, No. 23) excises a wedge of bone with its base anterior. This not only helps in correcting the deformity but provides a fragment of bone which he inserts into the cleft in the femur after it has been divided and straightened (Fig. 1301).

III. **Cuneiform Osteotomy of the Femur.**—Expose the femur as in linear osteotomy, but make the incision through the soft parts more generous. With a chisel remove a segment of bone as in Figs. 1302 and 1303. This operation is calculated to correct a graver deformity than could the simple linear section.

IV. **Cuneiform and Trapezoidal Osteotomy** [illegible] **Knee.**—It is presumed that the femur, tibia, and patella a[illegible]

Step 1.—Apply an elastic constrictor to the [illegible] removed by a large **U** flap having its base [illegible] (it does not matter which).

Step 2.—With an amputating saw or with a [illegible] ment of bone. The upper cut through the bo[illegible] angle to the axis of the femur, the lower cut ne[illegible] of the tibia (Fig. 1304).

Step 3.—Attend to hemostasis. Place the div
tion (Fig. 1305). Close the wound with sutu
Apply dressings. Immobilize. The divided en
in apposition by being pegged or sutured togetl

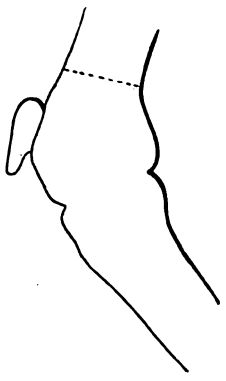


FIG. 1299.

FIG. 1300.

FIGS. 1299, 1300, AND 1301.—Anchy

immobilizing splint or dressing. The great obj
is the unavoidable shortening of the limb (*a*) fro
of bone, (*b*) from injury to, or destruction of, tl
young.

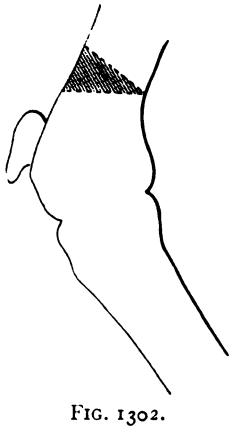


FIG. 1302.

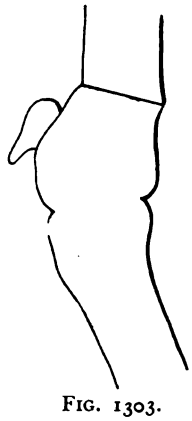


FIG. 1303.

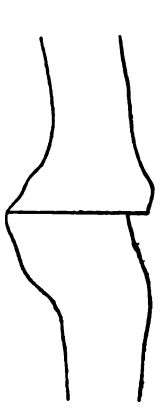
FIGS. 1302, 1303 AND 1304.—Anchylo

V. **Curvi-cuneiform Osteotomy.**—To avoid s
cuneiform osteotomy of the knee Helferich ("
346; xlvi, 445) devised a curvi-cuneiform operati

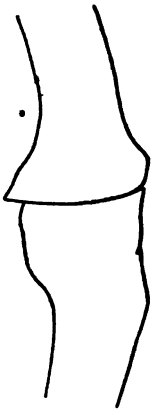
Step 1.—Apply an elastic constrictor to the thigh. Expose the anterior and lateral surfaces of the fused bones by a large U flap or by a transverse incision over the most prominent part of the deformity. Reflect the periosteum from the area of bone to be attacked.

Step 2.—Note the position of the epiphyseal line of the femur so as to avoid it. To find the line it may be necessary to shave off a thin slice of bone from the outer or inner side of the femur with a chisel. This exploration does no harm and may do much good. With a narrow-bladed finger-saw divide the extreme lower end of the femur in a curve corresponding to the antero-posterior curve of the condyles (Fig. 1304).

Make a similar curvi-linear section of the upper end of the tibia. The curve of the tibial section need not be so pronounced as that of the femoral. The result of the above is the removal of a curved wedge of bone; all that now



Cuneiform osteotomy
FIG. 1305.



Curvi-cuneiform osteotomy
FIG. 1306.

FIGS. 1305 AND 1306.—Anchylosis of the knee.

obstructs correction is the presence of contracture of the ham-strings and of fascia (Fig. 1306).

Step 3.—Through short longitudinal incisions on each side of the popliteal space divide the ham-strings and any obstructing fascia. Remember the location of and avoid injury to the peroneal nerve between the biceps and the gastrocnemius. Instead of carrying out a mere tenotomy, it might be well to unite the divided ham-strings to the quadriceps tendon. Correct the deformity without using too much violence. Helferich noticed that in some cases complete correction interfered with the vascular supply of the leg; under these circumstances he contented himself with partial correction at the time of operation, but gradually straightened the limb during the after-treatment before solidification had time to take place.

Step 4.—The divided bones tend to remain in apposition. Apposition maintained by pegs, bone, or periosteal sutures, or by splints outside for drainage. Close the wound. Apply dressings. position of great elevation. Remove elastic

N. B.—If desired, the elastic constrictor may be removed before the wound is closed and hemostasis be effected by ligatures. In excision of the knee the author has found that elevation of the limb has always sufficed for hemostasis.

Anchylosis of Patella to Femur.—As an extreme rarity there may be bony anchylosis of the patella to the femur with complete integrity of the rest of the femoral articular cartilage. Immobility of course is the result. Helferich demonstrated the technical possibility of correcting this disability by division of the anchylosis and interposition of a flap of muscle. Cramer, without knowledge of Helferich's suggestion, made use of the same idea in a suitable case. Cramer's operation may be performed as follows:

Step 1.—Make a longitudinal incision on the inner side of the patella of length sufficient to give access to the line of anchylosis and to the lower part of the vastus internus.

Step 2.—With chisel and mallet separate the patella from the femur along the line of anchylosis.

Step 3.—Mobilize a flap of muscle from the vastus internus, the pedicle of the flap being inferior; tuck the muscular flap as smoothly as possible between the separated bones.

N. B.—Instead of a muscular flap, one of fat and fascia, as suggested by Murphy, may be used.

Step 4.—Close the wound. Dress. Begin exercises as soon as the wound is healed.

Arthroplasty.—Before deciding on operation it is necessary to note:

1. The character of the anchylosis—whether fibrous or bony and whether the joint cavity is or is not obliterated.

2. The condition of the muscles which should move the joint. If they are insufficient or destroyed, operation is evidently useless.

3. The condition of the periarticular structures. If they are soldered together into a mass of scar tissue arthroplasty is impossible.

4. That the disease causing the anchylosis is cured.

5. The general condition of the patient.

The principles on which the operation of arthroplasty depends for success are the following. (Strict asepsis is assumed.)

1. Free exposure of the joint by incisions which will do least damage.

2. Liberation of the anchylosed surfaces by means of knife, scissors, saw chisel, etc.

3. In case of bony anchylosis it is usually necessary to model the ends of the bone and to reduce their size. Payr recommends that this modeling be done on simple lines, no attempt being made to sculpture the end of the bone into its normal shape.

4. *Excision of all* the joint capsule as well as contracted bands of fibrous tissue and of ligaments. Both Murphy and Payr put much emphasis on this principle, and it certainly is based on common sense. Excision of ligaments and capsule not only aids directly in obtaining free motion, but indirectly also, as it means the removal of the articular nerve endings and thus minimizes post-operative pain and permits earlier and infinitely [illegible] motion. In ex-

ising the capsule and ligaments where they are inserted in the bone it is wise o shave away a piece of the bone with them.

5. Prevention of recurrence of the anchylosis. This is attempted by the nterposition of pedunculated flaps of living tissue (fat-fascia; muscle; tendon; endon sheath); free (*i.e.*, non-pedunculated) flaps or grafts of living tissue fascia; synovial bursæ; cartilage, etc.); grafts of foreign structures, *e.g.*, hog's ladder, prepared amnion, etc.

6. Careful hemostasis. Avoidance of drainage except if necessary by aspiration of any effused blood after two or three lays (Payr). Most surgeons use drainage.

7. Careful, methodical, persistent after-treatment.

Payr ("Münch. Med. Woch.," lvii, No. 37) varns against brusque passive movements as alculated to cause injury, and especially hemorhage, which can easily jeopardize the result deired. The same surgeon frequently prevents ressure by the ends of the bone on the interosed tissues by using direct extension by neans of Steinmann's nails.

As soon as the skin wound has united hange the position of the joint frequently. Keep the muscles in tone by massage, hot air, aths, electricity, etc. Payr finds injections of brolysin, repeated every second day, serviceble.

Gentle passive motion should be begun at nce and, what is of greater value, active motion. Tendon transplantation may be necesary to reinforce weakened muscles.

FIG. 1307.—Arthroplasty. (*Murphy.*)

Murphy's Operation.—Many researches Ledderhose, Langemak, Thorn, Franz, etc.) ave proved that ganglia and bursæ are the reults of a degeneration of connective tissue and hat the synovialis of joints is formed originally by identically the same process. J. B. Murphy, accepting these truths, applied them to the operation of arthroplasty. Applied to the knee-joint, his operation is as follows:

***Step* 1.—Apply the elastic** constrictor high up on the thigh. Make an external longitudinal incision from a point 6 inches above to a point 3 inches below he knee-joint (Fig. 1307). Do not incise the deep fascia except to the extent ecessary for opening the joint for overcoming the anchylosis. Make a 4-inch ertical incision over the inner side of the joint.

Step 2.—With scalpel, chisel, or saw, free the patella from the femur. Do ot divide the ligamentum patellæ or the quadriceps tendon.

Step 3.—Thoroughly divide and [illegible] the lateral ligaments of the knee. Murphy lays great stress upon this

ivide the adhesions.
saw and shape the end
ver end of the femur is cor
backwards.
with a thin layer of muscle
Fig. 1305). The ba-
The flap must be long enough to
and large enough to enve
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Dress. Immobilize
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tended position
except at drainage-t
opening, which remained open
weeks. When healing
an apparatus consisting
and a screw mechanism
movement of the joint was applied. Movement was so free from
screw was discarded and she was sent home on crutches. It is
be operation. The joint can be readily extended straight

xed at a right angle. The apparatus is essential to give stability to the int."

The author saw the patient two years after operation. Aided by the apratus, the patient walks well and comfortably.

Payr's Operation.—Payr's method of operating is in all essentials like that Murphy and Davis. Occasionally he provides artificial lateral ligaments silk and usually keeps the surface of the bone apart by weight and pulley action exerted directly on the upper end of the tibia by means of nails screwed to the bone (p. 916).

Implantation of Animal Membranes.—Baer ("Johns Hopkins Bulletin," ept., 1909) made experiments with the implantation of Cargile's membrane joints, but found that it was too delicate and too soon absorbed. Pig's ladder properly prepared and chromicized to last from thirty or forty days sufficiently durable, pliable and tough to answer the purpose. The kneeint is opened by lateral incisions, the anchylosis removed and the membrane pplied so as to be adapted to the whole contour of the joint and fixed in place sutures. "Every raw surface should be absolutely separated by it from that ith which it would normally come in contact." With the same object, porns of hernial sac or of amnion (Hermann Schmerz, "Zent. f. Chir.," Oct. 14, 11), washed in salt solution and preserved in 2 per cent. formalin solution, ve been employed.

Joint Transplantation for Anchylosis of Knee.—E. Lexer ("Archiv für n. Chir.," lxxxvi, 952) in 1908 described two cases in which he transplanted e entire knee-joint. The following is a very free translation of Lexer's deription. "One of these two cases was submitted to operation seven, the her four, months ago. In both there was synostosis with marked flexion, e, respectively, to suppuration and to tuberculosis. To expose the joint I rmed a large flap in front, having its convex lower end at the level of the tuberity of the tibia, so as to permit reflection of the remnants of the ligamentum tellæ and of the articular capsule with the flap. Only in the first case was e ligament present, while in both the capsule was destroyed. After exposing e synostosis in front, the soft parts, including the tendon insertions, were parated from the bones, both laterally and posteriorly, by sharp and blunt ssection. The sclerosed periosteum remained attached to the bone. The nchylosed joint was now excised in such a manner as to aid in reestablishing od position. In each case the defect left between the femur and tibia, when e limb was straightened, was about three fingers' breadth in extent. The nee was now excised from a freshly amputated limb. The portion used for ansplantation consisted of the entire articular surfaces and about 1½ fingers' readth of bone belonging to the femoral and tibial epiphyses. In both cases e crucial ligaments were intact; in the first case the semilunar cartilages were moved, while in the second case these were retained as were also the lateral sertions of the capsule. When the implant was placed in position it was ted to the tibia and femur by means of nails or wire.

"The ligamentum patellæ, preserved in one case, was sutured to the periteum. Healing took place in both cases. In the first case passive motion as impossible because the patella had been merely reflected and replaced at

the operation without having its under surface protected by interposed materi and so it became adherent. Three months later the patella was excised During this second operation the implant was inspected and proved to be solid in place and alive. Both patients have a small degree of motion (in one passi flexion to about 45°), and pain *neither* on walking nor standing. There is r lateral motion.

Remarks.—On reading Lexer's most delightful and brilliant article one reminded of the famous recipe for making hare soup, which began with the wor "first catch your hare." It is only fair to state that in Lexer's clinic there seem to be a large number of cases of senile gangrene without phlegmon, and it i from that source that he obtains his material for implantations.

Juxta- or Supra-articular Osteotomy.—Perkins' Operation.—This opera tion, devised and carried out by J. W. Perkins, is applicable to similar condi tions in various articulations, but is perhaps peculiarly appropriate in the knee The principles of the operation are: (*a*) Avoidance of injury to the articula structures and, in the young, to the epiphyseal line. (*b*) Avoidance of injury to, or undue stretching of, the great vessels and nerves of the popliteal space. (*c*) Rectification of deformity with retention of any power of movement which the joint may possess.

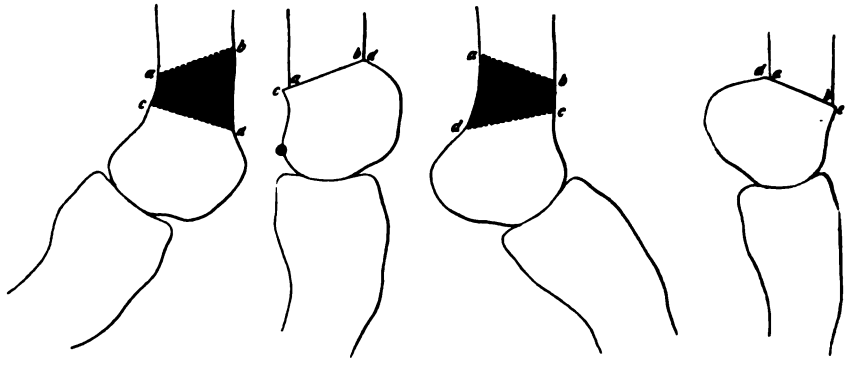


FIG. 1309. FIG. 1310. FIG. 1311. FIG. 1312.

FIGS. 1309, 1310, 1311 AND 1312.—Perkins's operation.

The operation is an extension of the basal principles of Macewen' supra condyloid osteotomy.

Example 1.—The knee is in a position of flexion; a moderate degree of further flexion is possible but no further extension. The structures (ligaments, tendons, vessels, etc.) posterior to the knee are contracted.

The Operation.—*Step* 1.—Make a longitudinal incision 2½ to 3 inches in length down to the bone on the inner side of the thigh. The lower end of this incision should be about ¼ inch above the epiphyseal line. If necessary, make a similar incision on the outer side of the thigh.

Step 2.—Separate the periosteum from the bone and retract the soft parts and periosteum together so as to expose a sufficient area of bone.

Step 3.—With osteotome, chisel, or saw excise the rhomboid of bone (Fig. 1309). The segment of bone removed must be sufficient to per

to be straightened. The short side of the rhomboid (ac) must be long enough so that when the limb is straight the structures behind the knee are not unduly stretched.

Step 4.—Straighten the limb (Fig. 1310). Close the wound with or without drainage. Treat as a fracture.

Osgood (Surg., Gyn., Obst., xvii, 664) describes an operation very similar to that of Perkins.

Example 2.—**Genu Recurvatum.**—The knee is in a position of hyperextension (dorsal flexion). Further extension (dorsal flexion) is possible, but only adds to the deformity and disability. Operate as in Example 1, but make the base of the rhomboid *posterior* instead of anterior (Fig. 1311). Remove so much bone that when the divided ends of bone are put in apposition the whole limb is straight while the knee-joint is in its position of greatest hyperextension (Fig. 1312). Shortening of the flexor tendons of the knee may be necessary.

Wreden's Operation.—("Russki Wratsch.," 1910, No. 6, Ref. "Zentralblatt für Chir.," 1910, No. 22.) Occasionally some motion remains in a knee which has recovered from tuberculous disease but is in a position of flexion. In these cases Wreden's operation may be used.

Through an appropriate incision (Wreden uses a Y-shaped incision) expose but do not open the upper synovial pouch of the knee. Reflect downwards the synovial pouch along with the periosteum of the femur. Divide the femur transversely close to the knee; make the lower end of the shaft of femur protrude from the wound and with a saw "sharpen" the end of the bone like a lead pencil. In the sawn surface of the epiphysis construct a hole suitable to receive the pointed end of the diaphysis. Push the end of the diaphysis, like a peg, into the hole in the epiphysis after straightening the limb. The principle of the operation is the same as that of Perkins' method.

CHAPTER LXXXV

DISLOCATION OF THE PATELLA

Recent outward dislocation of the patella may be irreducible without operation when the ligamentum patellæ becomes caught under the external condyle of the femur, or when there is such rotation of the patella on its long axis that its cartilaginous surface faces forwards. A longitudinal incision made to the inner side of the patella permits of reduction and at the same time gives an opportunity to suture the torn inner capsule and any fibres of the vastus internus which may be ruptured.

In old unreduced patellar dislocations there is always lateral elongation of the capsule on one side of the bone and there may be cicatricial contraction on the other side. (The dislocation is almost always outwards, hence the elongation of the capsule is on the inner side.) If disability is marked, operation is demanded.

Make an incision to the inner side of the patella and open the joint. If possible reduce the dislocation and shorten the elongated capsule laterally

either by excising an elliptical segment and closing the wound by sutures or l closing the original longitudinal wound in such a fashion as to make one ed of the wound overlap the other. If contraction of the outer portion of the ca sule renders reduction by simple arthrotomy impossible, a longitudinal incisi may be made through the contracture. Access to the portion of capsule fault may be obtained, according to circumstances, (*a*) through the origi wound, through the joint cavity, under the patella, the capsular division bei made from within outwards; (*b*) through the original wound by dissecting t skin from over the patella, retracting the skin and cutting the capsule from wi out inwards; (*c*) through a special incision.

If hemostasis is complete close the wound without drainage, otherwise ins a drain of rubber tissue or oil-silk for about twenty-four hours. Dress. Imm bilize in a semi-flexed position until the wound has healed. After two wee begin massage and passive motion. Walking may usually be begun in abo five weeks.

Recurrent or Habitual Dislocation of the Patella.—When orthopedic appar tus proves inefficient or inconvenient, operation is indicated.

The principal conditions favoring the occurrence of habitual dislocatio (Hildebrand) are the following:

1. External condyle absolutely or relatively less prominent than interna condyle.

2. Patellar fossa too small.

3. Genu valgum.

4. Abnormal external rotation of the lower leg.

5. Abnormal laxness of the quadriceps femoris or of the ligamentum patellæ.

6. Injuries of the capsule, tears of the capsule or of the vastus internus or it tendon which have healed and stretched.

7. Stretching of the capsule in genu valgum, *e.g.*, occasioned by hydrops, etc A longitudinal incision along the inner side of the patella down to, but no through, the joint capsule permits examination as to its laxity. If laxity of th capsule is the main lesion, it is easy (*a*) to excise an ellipse from it and close th wound with sutures, (*b*) to incise the capsule and close the wound in such fashion that one edge overlaps the other, or (*c*) to catch the *unopened* capsule forceps, throw it into folds and fix these folds with sutures.

If the dislocation is due to improperly united tears of the vastus interna and its tendon, the same longitudinal incision exposes such, and they may be repaired that the muscle can once more act properly on the patella. Traumat hydrops may cause habitual dislocation in a knock-kneed subject. Osteotom correcting the knock-knee has cured the dislocation (Hildebrand). Hildebran reports a case in which there was a flattening of the external condyle bu no knock-knee; when the knee was extended there was incomplete luxatio but in flexion the luxation disappeared. The tuberosity of the tibia was tran planted inwards; the result was excellent.

The above hints show that in habitual dislocation of the patella th surgeon must not be governed by hard and fast rules, but must as far a possible be guided in his treatment by a study of causation.

Goldthwaite's Operation.—In uncomplicated cases of recurring dislocation of the patella Goldthwaite's operation, either alone or plus capsulorrhaphy, is excellent.

Step 1.— Expose the tendo patellæ freely through a longitudinal incision.

Step 2.—Split the tendon longitudinally. Divide the outer half of the tendon transversely at its insertion into the tibia thus forming a tendon flap which has its base above the patella.

Step 3.—With closed scissors or forceps burrow under the inner (intact) half of the patellar tendon, pull the mobilized flap of tendon through this tunnel and unite it by sutures to the periosteum and to the expansion of the tendon of the sartorius muscles (Fig. 1313).

FIG. 1313.—Goldthwaite's operation.

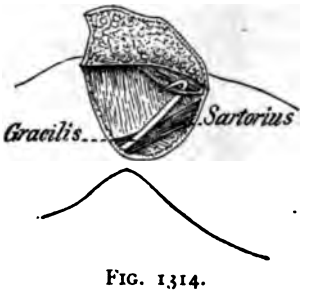


FIG. 1314.

Whitelocke's Operation—(Brit. Journ Surg., II, 12).—1. Reflect a large, horseshoe-shaped flap of skin and fascia with its base in front and its apex reaching backwards to the line of the medial ham-strings. The base of the flap corresponds to the medial margins of the patella and its ligament.

2. Expose the ligamentum patellæ for about ¾ inch and perforate it for about ½ inch in the middle line.

3. Recognize the Sartorius muscle by the direction of its muscular fibres. Divide the fascial attachment of this muscle above and behind and retract its posterior edge forwards to expose the tendon of the gracilis which lies proximal to the semitendinosus. Free the gracilis from its surroundings, being careful not to injure some vessels and a nerve which run parallel to it. Divide the gracilis close to its tibial insertion as possible. At its insertion the tendon spreads into a thin expansion about 2 inches in vertical diameter.

Pull the end of the tendon from behind forwards through the split made in the ligamentum patellæ and fix it there with sutures (Fig. 1314). ndon in its new position passes almost horizontally forwards around and e internal tuberosity of the tibia. With a few stitches, which should not te the joint, anchor the tendon in its new course to the articular capsule. [redacted] of the edge of the Sartorius which were dissected in

to reach, without tension, to the ligamentum of that ligament and sew its free end to

5. Close the wound. Dress. Apply a posterior splint for about ten or until the wound has healed.

Wullstein's Operation.—In a severe case of external congenital dislo of the patella Wullstein ("Zentralblatt für Chir.," 1906, No. 38) that the inner portion of the joint capsule was excessive in quantity the outer was correspondingly narrow. He operated as follows:

Step 1.—By means of a horseshoe-shaped incision reflect upwards a large flap of skin from over the knee-joint and thus expose the anterior and of the lateral aspects of the joint as well as the ligamentum patellæ to bel tibial tuberosity and the quadriceps tendon to a point above the superior of the synovialis.

Step 2.—By blunt dissection separate the quadriceps tendon and the mentum patellæ from the underlying portion of the joint capsule.

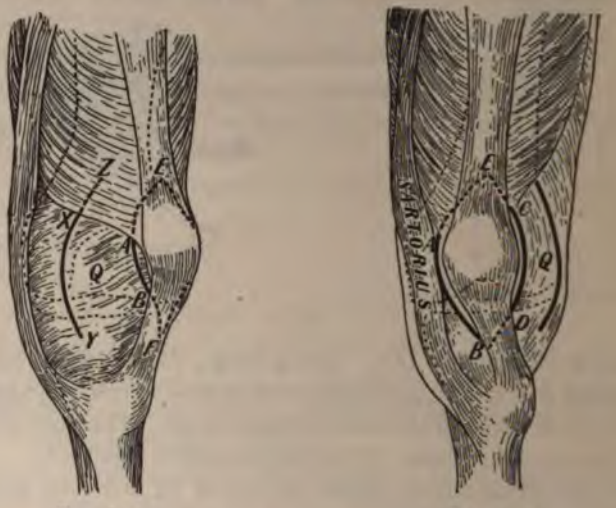


FIG. 1315. FIG. 1316.

FIGS. 1315 AND 1316.—Wullstein's operation. (*Wullstein.*)

Step 3.—To the outer side of, and about ¼ inch from the patella inci capsule (both fibrous and synovial) along the line C D (Fig. 1316). Mak corresponding incision A B (Figs. 1315 and 1316) on the inner side of the p Retract and elevate the quadriceps muscle and tendon from the upper of the synovialis and continue the incision A B and C D upwards to meet point E corresponding to the highest part of the joint cavity. Elevate or r the ligamentum patellæ and continue the incisions A B and C D downwa meet at the point B.

Step 4.—Push the patella inwards to the extent necessary for correction deformity. Note how much of the inner portion of the capsule is excessiv guided by that information make the incision X Y (Fig. 1315) parallel to Retract the vastus internus and continue the cut X Y under the vastus t point Z.

Step 5.—The incisions F B A E and Y X Z form a flap Q of joint capsule o inner side of the joint. Transfer the flap Q under the patella from the in

:he outer side of the joint. When the patella is pushed into its correct position :he wound made by the incision E C D B (Fig. 1316) gapes. Into this defect on :he outer side of the joint suture the flap Q.

Step 6.—Suture the capsular wounds.

Step 7.—Mobilize the sartorius muscle and suture its outer edge to the inner :dge of the patella. This aids in keeping the patella in position.

Step 8.—Close the wound. Dress. Immobilize.

CHAPTER LXXXVI

ANKLE

Puncture and Injections.—Krause recommends that the trocar puncture the :issues vertically immediately below one or the other malleolus and then that ts points be directed upwards. If injections are necessary they may be made nore definitely through an arthrotomy incision than by means of the trocar. The material used for injection varies (carbolic solution, formalin-glycerine, odoform in glycerine, oil or ether, etc.).

Arthrotomy.—*Step* 1.—Make a 2-inch vertical incision along the anterior ›order of the external malleolus and ending about ½ inch below the tip of :he malleolus. The extensor tendons and the ›eroneus tertius lie to the inner side of the incision. Divide the annular ligament. Open the joint mmediately in front of the malleolus.

FIG. 1317.—Drainage of the ankle. (*Labey.*)

Step 2.—Pass a closed forceps through the ›bove incision across the ankle to the inner side ›f the limb (Fig. 1317). The forceps must be in :ontact with the bone, must pass through the oint itself and so lie behind the synovial sheath ›f the extensor tendons. Make the point of the orceps raise the soft parts immediately in front of he internal malleolus. Divide the soft parts over he point of the forceps. If tubular drainage is lesired it is easy to pull a tube through the joint. Experience shows that a tube in a joint is very ›armful and thus if a tube is used it must never penetrate the synovialis. Willems' ›rinciples of immediate active motion as the best means of drainage (p. 1031) nust be remembered though as Chutro remarks such may be difficult to carry ›ut and if pain is absent it might be wise to use the Wassermann test lest the vant of pain be due to specific disease.

If instead of draining the joint it is desired to fill it with iodoform emulsion or uch like material, this may b[illegible]ne through the incision and the wound closed vith sutures.

Step 3.—If the single or [illegible]nterior arthrotomy wound is insufficient or drainage, it is easy to mak[illegible]r counterpuncture on the outer side of he tendo achillis. If it is nec[illegible]ncise on the inner side of the tendo

achillis, remember the position of the posterior tibial vessels and nerve as well as the flexor tendons of the foot and avoid them.

Excision of the Ankle.—Langenbeck's Subperiosteal Resection of the Ankle.—Lay the foot, inner side downwards, on a firm sand-bag. On the posterior margin of the fibula make a longitudinal incision 1½ to 2½ inches in length, directly to the bone. The lower end of the cut is opposite the tip of the malleolus. Some surgeons prefer an I-shaped incision on the outer surface of the fibula (Fig. 1318).

With periosteal elevator separate the periosteum and soft parts together from the external and anterior surfaces of the bone. At the lower end of the malleolus it is necessary to supplement the blunt dissection by cutting with scissors or knife. In cutting, the edge of the knife or the point of the scissors

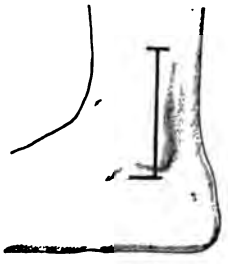


FIG. 1318.

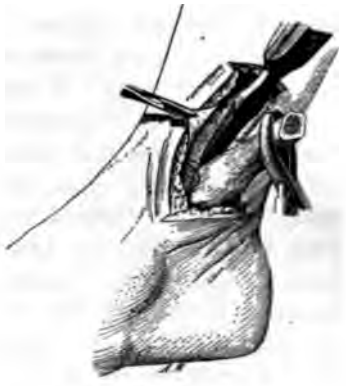


FIG. 1319.

FIGS. 1318 AND 1319.—Excision ankle. (*Labey.*)

must be directed against the bone to avoid injury to the periosteum and soft parts. This shelling of the soft parts from the bone is carried forwards to the synovial insertion, which is also separated from the bone.

In similar fashion clear the posterior surface of the fibula of its coverings until the interosseous ligament is reached and divided. The ligament should be injured as little as possible. Chose the point at which it is desired to divide the fibula. Protect the soft parts with a retractor or periosteal elevator and divide the bone with a Gigli wire saw or chisel (Fig. 1319). Seize the upper end of the sawn off portion of bone with lion forceps, pull it outwards, divide or separate all adhesions with the elevator, knife, or scissors and remove the bone. Lay the foot on its outer side. Make a vertical incision from the tip of the internal malleolus upwards for 2½ inches along the middle line of the tibia. If desired one may supplement the vertical by a transverse curved incision at its lower end or by a transverse incision at each end. The periosteum is divided at the same time as the skin. With straight and curved periosteal elevators separate the periosteum and all structures superficial to it (tendons, vessels, nerves, etc.) from the bone. Divide the tibia with a saw or chisel at the same level, if possible, as the fibula. With forceps, pull the lower fragment of bone outwards and downwards, at the same time severing its con[illegible] to the interosseous membrane

and articular capsule with the periosteal elevator, knife, or scissors. Remember always to cut *against* the bone so as to avoid unnecessary injury. Remove the bone.

(Ollier advises that the bones should be divided obliquely; the line of section being from above and within, downwards and outwards. He states that by so proceeding greater solidity of the ankle results.)

Examine the astragalus. If it is diseased, but not to a serious extent, remove the diseased tissues with the sharp spoon or chisel. With forceps and scissors trim away ragged and loose pieces of cartilage. If it is necessary to remove the whole superior portion of the body of the astragalus this may be accomplished with the chisel or saw. If the saw is used the soft parts must be protected by using suitable retractors or by holding them aside and covering them with periosteal elevators. Pack the cavity of the wound with iodoform gauze leaving the incisions open, or partially close the incisions with sutures and provide tubular drainage. If no secondary infection is present, the wound cavity may

FIG. 1320.—Skeleton splint for injuries near the ankle-joint. (*Robert Jones, British Med. Journ.*)

FIG. 1321.—Skeleton splint applied. (*Robert Jones, British Med. Journ.*)

be filled with Mosetig's iodoform plug or some equivalent and closed without drainage. Dress. Immobilize preferably with Jones' splint (Figs. 1320, 1321). If plaster of Paris is used while it is hardening the foot must be held in a position at right angles to the leg and neither everted nor inverted. If much shortening is expected the foot may be held in a position of slight plantar flexion.

König's Operation.—König's operation gives admirably free access to the ankle-joint and is specially indicated in tuberculous disease where it is important to expose, observe, and treat not merely the ankle itself but the bones and joints which lie near it. From a point on the anterior margin of the tibia 1½ to 2½ inches above the ankle-joint and immediately internal to the extensor tendons make an incision downwards and forwards over the articulation, over the inner side and neck of the astragalus to end in front of the prominence of the scaphoid. On the outer side of the ankle make a similar incision along the anterior surface and margin of the fibula, across the articulation and ending on the outer side of the cuboid at the level of the astragalo-scaphoid joint. With forceps, knife, and elevator separate the whole bridge of tissue between the two cuts, from the underlying bones (Fig. 1322). If the case is one of tuberculosis, put the foot in a position of dorsal flexion, lift the tissue bridge out of the way with a blunt hook, examine the whole anterior articular region, remove by dissection, the anterior synovialis, and, if a partial operation will suffice, remove

any diseased bone with chisel and spoon. König writes: "If a lar present in the astragalus there is always danger that the three n joints are affected and one must, as a rule, remove the astragalus. Th

FIG. 1322.—Excision of ankle.

FIG. 1323.—Excision of ankle.

may be effected through either incision, preferably through the inner, of forceps, scissors, and knife with the assistance of strong periosteal After the astragalus is removed a good view can be had of neighboring and from them diseased foci, if limited in extent, may be removed.

If before the astragalus is removed it is known that the malleoli ought to be excised one proceeds as follows:

Make the incisions as already described down to the bone, but, although dividing the periosteum do not separate it from the malleoli (Fig. 1323). Introduce a broad-bladed chisel into the wound and cut from the outer surface of the malleoli a thin shell of bone. This osseous shell is covered by its periosteum which is continuous above with the periosteum of the tibia or fibula as the case may be and below with the lateral ligament. Retract the shell of bone outwards along with its attachments, divide the rest of the bone transversely with the chisel, and remove the fragment. The rest of the operation is to be carried out as already described. By the above procedures even the calcaneal and scaphoid joints can be reached and treated.

The active operation being ended, clean the wound cavity and rub it with iodoform, provide drainage either with tubes or iodoform gauze, partially close the wound with sutures, press the loosened shells of bone inwards, and apply dressings. As an alternative, fill the cavity with Mosetig's iodoform wax and close without drainage. Immobilize as in Ollier' operation. As anchylosis is desired, the after-treatment consists in keeping the parts at rest until they have become firm. If sinuses form and persist they must be dilated or opened and their cause removed.

Ochsner's Method.—Operation.—An incision is carried directly across the anterior surface of the ankle from malleolus to malleolus through the skin superficial and deep fascia and the sheaths of all the tendons in the course of the incision. Externally the peroneal artery and nerve should be avoided, as well as the tendons of the peroneal muscles, which can readily be drawn out of the way. Internally the posterior artery and nerve should be protected. Each tendon is then lifted up in the incision and transfixed with two fine catgut sutures from 1 to 2 centimetres apart. These sutures are caught in similar artery forceps for purposes of identification, then the tendon is cut transversely between these sutures (Fig. 1324). After all the tendons have been disposed of in this manner, the joint is opened by a free transverse incision and the sole of the foot is forced back upon the calf of the leg. In this manner the entire joint is opened freely, so that all diseased tissue can be removed. After this has been accomplished, the foot is placed in position, the tendons are carefully adjusted, which can be done with great ease, because the two sutures upon two corresponding tendon ends are fastened to hemostatic forceps of the same pattern. Each tendon is carefully sutured and a fine stitch is placed in the fascia to cover the line of suture in the tendon. Then the skin is sutured over all. If drainage seems necessary, this is applied through and through, and even in cases apparently requiring no drainage, I have usually passed a few strands of catgut or silkworm-gut entirely across the foot, permitting the ends to protrude from the lower angles of the wound in order to drain the serum which may be secreted by the large surface during the first few days. A large dressing is applied and the foot is immobilized in a position at a little less than right angle.

After-treatment.—The foot is elevated in order to favor return circulation. If drainage has been employed, this is left in place from one to two weeks. The dressing is not changed, unless this is indicated by the discharge, for a

week or ten days, in order to avoid moving the foot, and after that as seldo as possible for the same reason.

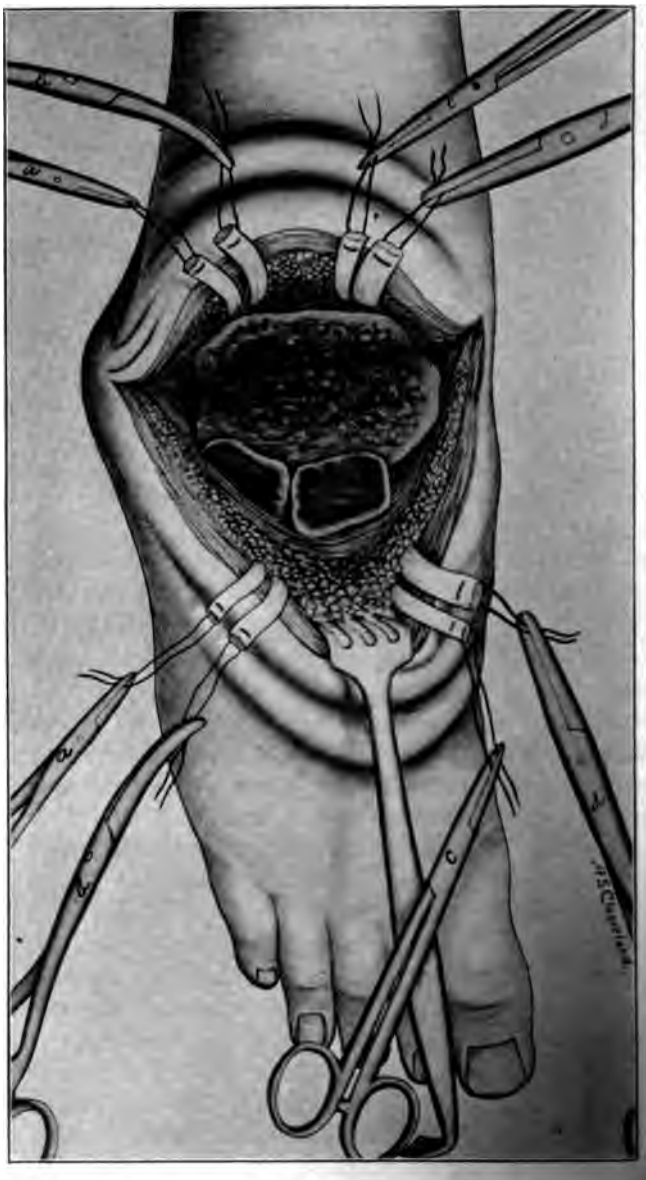


FIG. 1324.—Excision of ankle. (*Ochsner.*)

Prognosis.—The prognosis is very good after this operati exposure of the surfaces insures thoroughness, and conseque usually permanent. The anchylosis of the surfaces imm of operation does not interfere with movement becau joint will supply the motion necessary. The tendo

normally. There is no operation for the relief of joint tuberculosis that has given me more satisfaction than this one just described. With this method it is possible often to obtain a useful foot in cases which formerly could only be relieved by an amputation (Ochsner, "Clinical Surgery," p. 727).

Remarks.—Arthrotomy is indicated in cases of pyogenic arthritis to provide drainage. It may also be used as a preliminary to filling the joint cavity with iodoform emulsion. Arthrectomy is rarely indicated. The results are not usually very gratifying and amputation is usually the operation of choice when conservative treatment and minor operations fail.

CHAPTER LXXXVII

DISLOCATION OF THE ASTRAGALUS

Occasionally the astragalus is dislocated from both its superior and inferior connections. Reduction always requires a general anesthetic, and as failure to reduce by manipulation is probable, the surgeon ought to be prepared to operate at once. The bone so presses upon the soft parts that gangrene of the skin is sure to result, unless reduction is effected or the bone excised.

Make an incision on the inner side of the ankle from a point 1 inch above the articular surface, just in front of the malleolus, downwards and forwards to the internal cuneiform bone. Avoid injury to the tendon of the tibialis anticus. Separate and retract all the soft parts covering the astragalus. Endeavor to effect reduction by exerting traction on the foot and pressure on the astragalus. If this fails, and if more free access promises some prospect of success, make a corresponding incision on the outer side from just above and in front of the external malleolus downwards and forwards to the cuboid. Expose the parts involved. Once more attempt reduction. If the attempt still fails, remove the astragalus. Astragalectomy gives such good results that it is foolish to run much risk in striving after the more ideal operation. If the astragalus is completely separated from its connections or nearly so, then its removal must be the rule. When the dislocation is complicated by fracture and especially when it is compound (open) and infection is probably present, astragalectomy followed by drainage is the procedure of choice.

Katzenstein.—("Zent. für Chir.," 1912, No. 6.) In a chronic or recurring dislocation at the astragalo-navicular joint due to rupture of the tibio-navicular ligament and causing much disability, pain and flat foot, Katzenstein obtained a perfect anatomical and functional result by the following operation: Reduce the dislocation; expose by incision the surface of the internal malleolus and the navicular bone; from the tibia or any convenient bone, obtain a non-pedunculated flap of periosteum, fold this flap transversely so that its periosteal surfaces are in apposition except at both extremities; vivify a small surface on both the internal malleolus and the navicular bone and to these surfaces suture the ends of the periosteal flap; close the wound; immobilize in a position of valgus. After 5 or 6 weeks begin passive and later active motion.

CHAPTER LXXXVIII

SUBASTRAGALOID DISLOCATION

If manipulation under an anesthetic fails to reduce, operation is demanded. Baumgartner and Huguier ("Revue de Chir.," Aug., 1907) divide the cases requiring operation into two classes according to whether the astragalus is or is not fractured.

I. **The Astragalus is not Fractured.**—Reduction by arthrotomy is the operation of choice. Make an incision directly over the prominent head of the astragalus. Recognize the structures obstructing reduction. If these are ligamentous bands, divide them in one or more places (Quénu); if they are displaced tendons (*e.g.*, the tendon of the tibialis anticus sometimes lies along the inner and upper part of the neck of the astragalus which is then tightly held between it and the calcaneo-scaphoid ligament) (Stimson) the tendons may be pushed aside, or if this is impossible they may be divided and reunited after reduction is obtained.

Reduce the dislocation by manipulation, especially by flexing the foot, and by direct pressure. Close the wound with sutures. Dress. Immobilize for about three weeks. If reduction by arthrotomy fails, it is easy to proceed to astragalectomy, either complete or incomplete. Only so much of the astragalus ought to be removed as will permit of the foot being placed in a good, useful position.

II. **The Astragalus is Fractured as well as Dislocated.**—(*a*) The fracture affects the neck alone. The separated and dislocated head of the bone may be reduced or removed according to circumstances.

(*b*) The body of the bone is fractured. Astragalectomy is usually the best procedure to adopt. In compound (open) dislocation the indications for operation are much the same as given above. Astragalectomy, then, is indicated in cases of subastragaloid dislocation, (1) when the luxation is irreducible or operative reduction has failed; (2) when infection is present; (3) in old cases.

CHAPTER LXXXIX

OS CALCIS

Exostoses on the Plantar Surface of Os Calcis.—Exostoses in this position
igs. 1325, 1326) are not extremely rare, but may be disabling on account
pain. Operation is demanded when relief is not obtained by the use of a

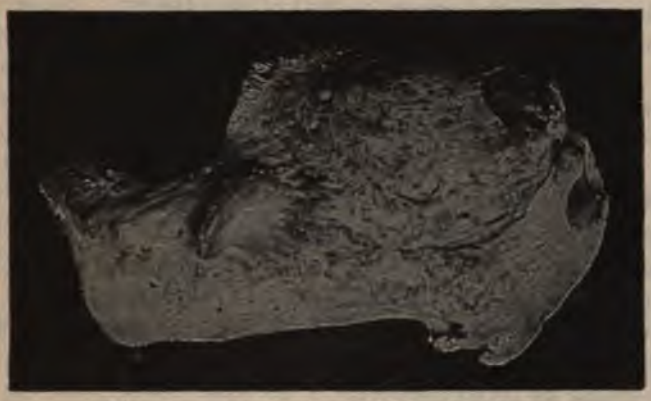


FIG. 1325.—Exostosis os calcis. (*Bradford.*)

shioned heel. Make an incision along the inner side of the foot close to the
le and opposite the site of exostosis. By sharp and blunt dissection expose
e affected portion of os calcis.

FIG. 1326.—Exostosis os calcis. (*Bradford.*)

With a chisel remove the bony spur. Close the wound with or without
ainage.

CHAPTER XC

BUNION (HALLUX VALGUS). HAMMER TOE METATARSALGIA

Hallux valgus consists in an inward* deviation of the great toe, the last phalanx of which may lie transversely across the second toe. The head of the metatarsal bone is pushed outwards, is usually enlarged, and part of its articulating surface is no longer apposed to that of the phalanx. Between the bone and skin there is a bursa formed which frequently becomes inflamed (bunion).

Dwight has described a supernumerary bone which occasionally exists between the bases of the first and second metatarsals. To this bone he has given the name intermetatarseum. The intermetatarseum may be free or may be fused with the first or the second metatarsal or with the internal cuneiform bone. J. K. Young believes that Dwight's bone is the cause of some forms of hallux valgus and if detected by the X-rays in an early case of deformity its removal should arrest the condition and relieve all symptoms. Young has performed the operation on a case of six years' duration.

Barker's Operation (Metatarsal Osteotomy).—Support the outer side of the foot on a sand-bag.

Step 1.—Make an incision directly to the bone, about one inch long, over the prominence of the metatarsal head, on the inner side of the foot.

Step 2.—With a chisel divide the metatarsal bone transversely at a point about ½ inch from the head. If the deformity is great instead of simply dividing the bone, excise a wedge from it.

Step 3.—Straighten the toe. Apply dressings. Immobilize.

Hueter's Operation (Metatarso-phalangeal Arthrectomy).—*Step* 1.—By manipulation locate the metatarso-phalangeal joint. Make a longitudinal incision on the inner side of the foot sufficient to expose the joint and the immediately adjoining bones.

Step 2.—With a chisel shave off sufficient of the articular ends of the metatarsus and phalanx until correction of the deformity is easy.

Step 3.—Close the wound. Apply dressings. Immobilize in correct position.

Riedl's Operation.—Osteotomy of the Cuneiform Bone.—*Step* 1.—Make a longitudinal incision on the inner side of the foot sufficient to expose the internal cuneiform bone and its articulation with the first metatarsal.

Step 2.—Avoiding injury to the insertion of the tibialis anticus, cut a wedge of bone from the cuneiform. The wedge must have its base on the external (fibular) side (Fig. 1327). The thickness of the wedge corresponds to the amount of metatarsal adduction.

Step 3.—Through the wound in the bone with strong scissors or knife cut around the external angle of the base of the first metatarsal bone so as to mobilize it.

* The word "inward" is used in relation to the middle line of the foot.

Step 4.—Place the metatarsal bone in correct position (Fig. 1327).

Step 5.—Correct the position of the great toe by some of the methods described.

Step 6.—Attend to hemostasis. Apply dressings. Immobilize.

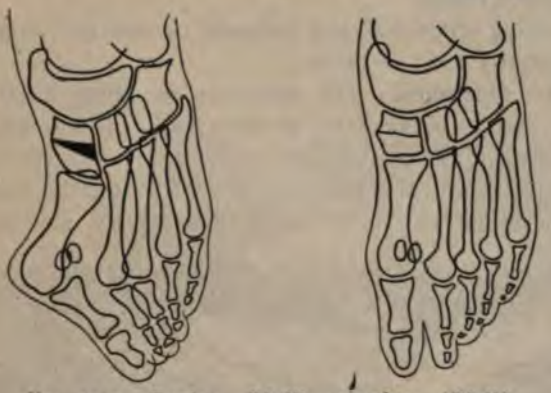


FIG. 1327.—Bunion. Riedl's operation. (*Riedl.*)

Riedl's operation is only suitable in cases of very great deformity of the first metarsal when rectification at the metatarso-phalangeal articulation would be insufficient.

Robert F. Weir's Operation.—On the inner side of the foot make a longitudinal curved incision beginning "in front at the hollow of the phalanx (Fig. 1328), running downwards towards the sole, and enroaching but slightly on

FIG. 1328.—Bunion. Weir's operation. (*Weir.*)

it, and passing backwards and upwards to the middle of the metatarsal bone." Reflect the flap thus outlined. With a chisel or bone forceps excise such portions of bony exostosis as prevent reduction of the deformity. Freely divide the inner* side of the joint capsule (*i.e.*, the side next to the second toe). If the sesamoid bones are dislocated outwards, remove them. Divide the dorsal tendon near its insertion and suture it to the periosteum at the outer* side of the base of the first phalanx. Close the wound. For two or three weeks keep a pad of gauze between the great and second toes to help hold the replaced

* The words "outer" and "inner" are used in relation to the middle line of the foot and not of the body.

toe in position. In the hands of Weir the above
results. Weir remarks: "No operation for the ha
does not, before suturing, allow the toe to rest
If any tilting then results, its cause must be inve
imperfect result will ensue."

In the preceding operations any inflamed or
the osseous deformity must be excised.

C. H. Mayo's Operation.—This operation rec
head of the metatarsus is calculated to leave a sti
defect. (1) Reflect a flap of skin (Fig. 1329) dov
the metatarso-phalangeal articulation. Do not i
a flap of the subjacent soft parts with its base a

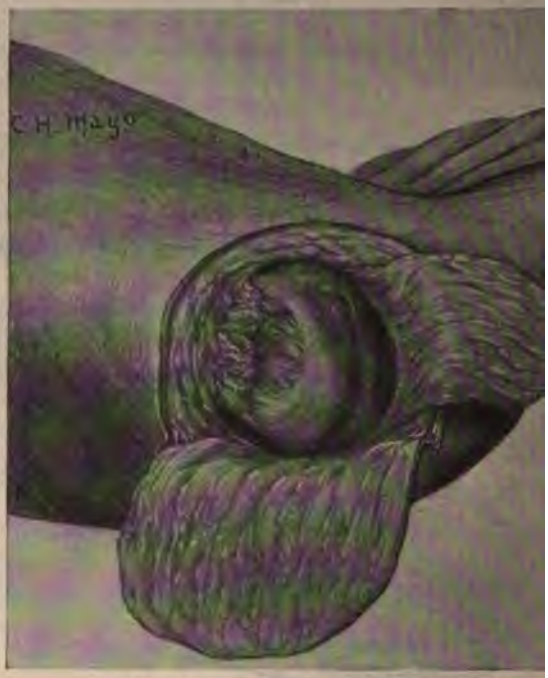


FIG. 1329.—Bunion. C. H. Mayo's oper

Reflect this flap and *with it* the bursa (Fig. 1329)
valgus excise the head of the metatarsus and shav
If necessary, excise the articular surface of the pr
toe (Fig. 1330). (4) Turn the flap containing the
the metatarsus and the phalanx and fix it there b
1331). The bursa having the same structure as a
excised joint. (5) Pull the dorsal flexor tendon o
to lie over the middle of the new joint and fix its
few sutures. (6) Close the external wound. Ap
wound and between the first and second toes. Th
to walk in a few days. The results are excellent.

FIG. 1330.—Bunion. Mayo's operation. (*Mayo.*)

FIG. 1331.—Bunion. Mayo's operation. (*Mayo.*)

as the best operation for bunion. If, when the patient is first seen, the bunion is inflamed, it must be treated until the trouble is quiescent before operation is attempted.

HALLUX RIGIDUS consists of a painful stiffness of the first metatarso-phalangeal joint. If a bar fixed to the sole of the shoe behind the articulation does not give relief and if there is much disability, excision of the head of the metatarsal with arthroplasty as in bunion, constitutes efficient treatment.

Hammer Toe.—When hammer toe is causing much disability and non-operative measures have failed or seem unsuitable several methods of operating are available.

1. Hoffa strongly recommends Peterson's operation, viz., transverse section of all the soft parts on the plantar side of the toe opposite the first phalango-phalangeal articulation, extension, application of dressings and of a splint. A cure may be expected in 4 or 5 weeks.

FIG. 1332.—Crooked heel shoe. Inner side heel is prolonged ¾-inch forward and is ⅓-inch higher than outer side. Bar of leather across sole proximal to head of metatarsals.

2. Excision of the first phalango-phalangeal articulation through a dorsal incision. Excise an oval piece of skin including the ever-present corn, from over the prominent knuckle. Excise a wedge of bone (base dorsal) including the joint, and sufficient in size to permit the toe to be straightened. Divide the contracted flexor tendon. Close the wound so as to have a transverse scar. Apply dressings and a plantar toe splint. The splint must be worn inside the shoe for several weeks until there is solid ankylosis. Robert Jones finds that it is unsatisfactory to remove the articular end of one of the bones constituting the joint, hence the advice to remove the whole articulation. Albee recommends a plantar incision to one side of the flexor tendon, excision of the offending joint and retention of the toe in a position of hyperextension by means of plaster of Paris.

3. Arthroplasty may take the place of excision, the cut ends of the bone being covered by a flap of fascia lata taken from the thigh or any convenient location.

Metatarsalgia.—When metatarsalgia cannot be relieved by the use of a crooked heel shoe to which has been added a transverse bar behind the heads of the metatarsal bones (Fig. 1332) the condition may be cured by excising the head of the offending metatarsal through a small dorsal incision. During convalescence the patient may walk provided he wears the shoe with the plantar bar.

CHAPTER XCI

OPERATIONS ON THE SCAPULA AND CLAVICLE

Scapula Alata. Deformity in Serratus Paralysis.—When the serratus magnus and the trapezius are paralyzed the scapula becomes very prominent and abduction of the arm impossible.

v. Eiselsberg united the two scapulæ so that they might support each other and thus permit abduction of the arm. When he succeeded in this the shoulders were pulled back so far that the clavicles compressed the vascular and nervous trunks of the arm against the first rib, and to overcome this it was necessary to make an oblique osteotomy of the clavicle

Duval gave stability to the scapula by uniting it to the sixth and seventh ribs ("Revue de Chir.," 1905, No. 1).

Duval's Operation.—*Step* 1.—Make an incision along the vertebral border of the scapula from the level of its spine down to its angle. Divide the trapezius and rhomboideus major throughout the extent of the wound. Retract the latissimus dorsi strongly downwards (Fig. 1333).

Step 2.—Incise the periosteum along the exposed border of the scapula and reflect it, along with the infraspinatus, from the bone for a distance of about ½ inch (Fig. 1333).

In the same manner separate the periosteum, along with the serratus magnus, from the deep surface of the scapula. *Excise* the periosteum and the serratus magnus to an extent sufficient to permit the denuded undersurface of the scapula to lie freely in contact with the sixth and seventh ribs.

Step 3.—At a distance of 2¾ inches from the middle line denude the sixth and seventh ribs of their periosteum. To give the scapula proper obliquity the denudation of the seventh rib should be about ½ inch further out than that of the sixth.

Step 4.—Unite the scapula to the ribs by two wire sutures as shown in Fig. 1334.

Step 5.—If possible, suture the periosteum over the wires.

Step 6.—Retract the inner edge of the wound (skin, trapezius, rhomboid) and expose the long muscles of the back lying on the posterior surface of the transverse processes in the upper angle of the wound.

Step 7.—From the long muscles of the back make a long and thick flap with its pedicle below. Suture this flap at the superior angle of the scapula to the periosteum and the supraspinatus.

Step 8.—Close the wound without drainage. Apply dressings and a plaster-of-Paris corset for forty-eight days.

Duval has operated three times. His first patient was able to work as a

waiter without trouble. The second patient was not improved.

Mencière ("L'Encéphale," March, 1912; "Lanc Duval's operation. Separate the periosteum from ribs, 9, 10 and 11 cm. respectively, from the mid attachment of the scapula will be oblique from abo and thus the acromion will be raised. Separation ribs permits sutures to surround these bones witho nerves. After completing the operation Mencière fixes the arm in an elevated position with the hand r After 65 days of this, immobilization exercises are

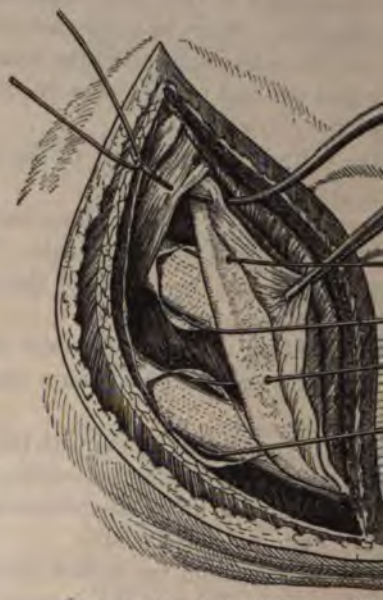


FIG. 1333.—Scapula alata. (*D*

Transplantation of Muscle in Serratus Paralys klin. Woch.," 1908, Dec. 28) operated in tw manner:

Stage I.—*Step* 1.—Make a longitudinal incision back from the third to the tenth dorsal spines. Ex of the trapezius and rhomboideus major arising fro

Step 2.—Reflect the divided muscles downward them snugly to the periosteum of the seventh, eigh latissimus dorsi.

Stage II.—*Step* 1.—Make a longitudinal incisi of the arm from its middle up, through the axilla to

Step 2.—Isolate and divide the humeral insert Free the muscle with its aponeurosis and suture its t and to the anterior scapular muscles.

The result was excellent both as regards appearance and function.

Muscle Transplantation in Paralysis of the Trapezius and Serratus Magnus.—In a case of complete paralysis of the *trapezius* due to division of its nerve, Katzenstein ("Berliner klin. Wochsch.," xlvi, No. 49) operated as follows:

First Stage.—Through a suitable incision expose the upper margin of the latissimus dorsi and by splitting the muscle, isolate a suitable bunch of its upper fibres; divide this isolated segment of muscle at its humeral insertion thus forming a flap with its pedicle posterior. Suture the free end of the flap to the posterior surface of the scapula below the origin of the triceps. This flap takes the place of the lower fibres of the paralyzed trapezius (Fig. 1334).

FIG. 1334.—(*Katzenstein.*)
1, 2, 3. Sup. Mid. and Inf. Segments of trapezius. 4. Latissimus dorsi. 5. Flap from lat. dorsi to trapezius.

Second Stage.—Through a suitable incision expose the upper part of the healthy (opposite) trapezius. Divide its clavicular insertion and carefully preserving its nerve supply form a muscular flap and suture it (Fig. 1335) to the spine of the scapula.

Third Stage.—Form a flap (Fig. 1336) from the middle of the healthy trapezius and suture its free extremity alongside of the flap formed in the second stage of the operation.

The result of Katzenstein's operation was functionally good. In complete paralysis of the serratus magnus and partial paralysis of the inferior fibres of the trapezius Katzenstein devised and carried out the following procedure:

FIG. 1335.—(*Katzenstein.*)
1. Sup. fibres of paralysed trapezius. 2. Flap from healthy trapezius.

FIG. 1336.—(*Katzenstein.*)
1, 2, 4. Sup. Mid. and inferior segments of trapezius. 3. Flap transplanted from left to reinforce right trapezius.

1. Division of the spinal origin of the rhomboid muscles and transplantation of their origin to lower vertebræ thus reversing the action of the muscles and making them assistants to instead of antagonists of the serratus magnus.

2. Division of the tendon of the pectoralis major at the level of the humerus and suture of it to the axillary border of the scapula so as to correct the *scapula alatum* which was present. The result was excellent.

Paralysis of Trapezius Muscle.—Treatment by "free" transplantation of fascia. *Rothschild's operation.* When the upper arm is raised above the horizontal this motion is due to the serratus magnus while the trapezius keeps the scapula sufficiently fixed so that the serratus is able to act with power. If the trapezius is paralyzed it becomes impossible to raise the arm unless the scapula is held in place by some artificial means. Rothschild accomplishes the fixation of the scapula in the following manner. ("Zeit. für Chir.," Nov. 5, 1910.)

Step 1.—Make an oblique incision from the upper and inner angle of the scapula, downwards to the first lumbar vertebra. Expose the vertebral border of the scapula, part of the paralyzed trapezius, part of the latissimus dorsi.

Step 2.—From the thigh excise a strip of fascia lata about 8 inches long and 1¾ inches wide.

Step 3.—Suture one end of the strip of fascia securely to the supraspinatus and its fascia. Suture the other end of the strip to the latissimus dorsi and deep muscles near the spine. Before suturing the vertebral end of the strip of fascia put so much tension on it that the scapula is pulled up to the level of its fellow on the opposite side and its vertebral border is parallel to the spine. In order to prevent adhesion between the fascial implant and the skin, Rothschild recommends that a small opening be made through the paralyzed trapezius near the scapula and that the flap be passed through this opening and conducted under the trapezius to the site of its suture to the trapezius. Rothschild has found this operation completely satisfactory.

Deltoid Paralysis.—Transplantation of Trapezius.—Dean Lewis' operation. ("Jour. A. M. A.," Dec. 24, 1910.)

Step 1.—Make a longitudinal incision from the middle of the outer border of the trapezius to the junction of the middle and lower thirds of the deltoid.

Step 2.—Divide the clavicular, acromial and part of the spinous attachments of the trapezius.

Step 3.—Separate the atrophied deltoid from the clavicle and spine of the scapula and turn it down.

Step 4.—Open the sheath of the long head of the biceps, lift up the tendon and plicate it (Kiliani) so as to correct the subluxation.

Step 5.—Suture the trapezius to the articular capsule where it is attached to the humerus.

Step 6.—Turn the flap of deltoid upwards over the trapezius and suture it high up while the arm is abducted.

Step 7.—Suture the upper part of the skin wound in such a manner as to make the cicatrix at right angles to the original direction of the wound. This helps to overcome the subluxation. Close the rest of the wound. The resulting scar is **T**-shaped, the horizontal arm of the **T** extending across the summit of the shoulders.

Step 8.—Apply dressings. Immobilize at an angle of about 100°. After about four or five weeks gradually lower the arm.

Excision of the Scapula.—Indication.—Malignant neoplasms of the scapula constitute the indication for its complete removal. As a rule, as much as possible of the muscles attached to the bone should be removed along with it, since sarcoma is liable to spread from the bone along the muscles (see remarks

on tumors of bone). If skin is involved, the incisions must be so planned as to surround the affected areas.

Potel in a case of spindle-cell sarcoma which involved almost all the scapula and the attached muscles excised the scapula but preserved the glenoid fossa thus keeping the shoulder-joint intact. Two and one-half years later the patient was well and had good function. Quénu in discussing Potel's report advised preservation of the glenoid fossa, but if this is impossible he advised fixation of the head of the humerus to the outer end of the clavicle (International Abstracts, Aug., 1914).

If the humerus or axilla are involved, the question of inter-scapulo-thoracic amputation at once arises. If the scapula is fixed to the chest wall, operation is usually contraindicated as the thorax is invaded.

Step 1.—Place the patient on his back. Abduct the arm. From the apex of the axilla make a 3-inch incision down the arm, immediately behind the anterior wall of the axilla, along the inner and posterior border of the coracobrachialis. Raise the anterior fold of the axilla and expose the coracoid process. With blunt-pointed scissors cut the three muscles attached to the coracoid close to the bone. This fully exposes the axillary artery. The subscapular artery "arises opposite the lower border of the subscapularis and runs downwards and inwards along the anterior border of that muscle under cover of the latissimus dorsi. * * * It is accompanied by two veins. * * * About 2.5 or 3.7 cm. (1 or 1½ inches) from its origin, the subscapular artery divides into two end branches: (1) the circumflex (dorsal) scapular, and (2) the dorsal thoracic" (Morris) (Fig. 1337). Recognize and ligate the subscapular artery. This step (Cheyne, Jacobson) saves much trouble from bleeding and the separation of the muscles attached to the coracoid greatly simplifies the later stages of the operation. The truth of these observations was agreeably impressed on the author in a case of gigantic enchondroma in which he was associated with Dr. Sudler.

Step 2.—Pack the axillary wound. Turn the patient on to his sound side and bring his back close to the edge of the table.

Incision A.—Make "a T-shaped incision, one limb running from the acromio-clavicular joint inwards to the superior angle of the scapula, while the other and longer is made at right angles to the first down to the angle of the scapula."

Incision B.—Make a ⊢-shaped incision, one cut running along the vertebral border of the scapula, the other at right angles to it across the centre of the growth.

Incision C.—Same as **B** except that the horizontal cut runs on the spine of the scapula and reaches to the acromio-clavicular joint or if a portion of the acromion is to be preserved, to the top of the acromion.

Step 3.—Incision **C** has been adopted. Reflect the two skin flaps formed by the ⊢-shaped cut. Examine the deltoid and trapezius muscles. If their condition is above suspicion, preserve them; if not, those portions which are attached to the scapula must be excised. Pass the finger under the deltoid and hook up the muscle. If the muscle is to be preserved divide its origin at the spine of the scapula and reflect the muscle outwards; if it is to be removed split the muscle along the junction of its scapular and clavicular portions.

Follow the scapular portion down to its insertion in the humerus and there divide it, leaving the muscle hanging attached to the scapula. The clavicular portion of the deltoid is left intact.

Step 4.—Expose and divide the following tendons which are inserted into or near the upper end of the humerus—subscapularis, the long head of the

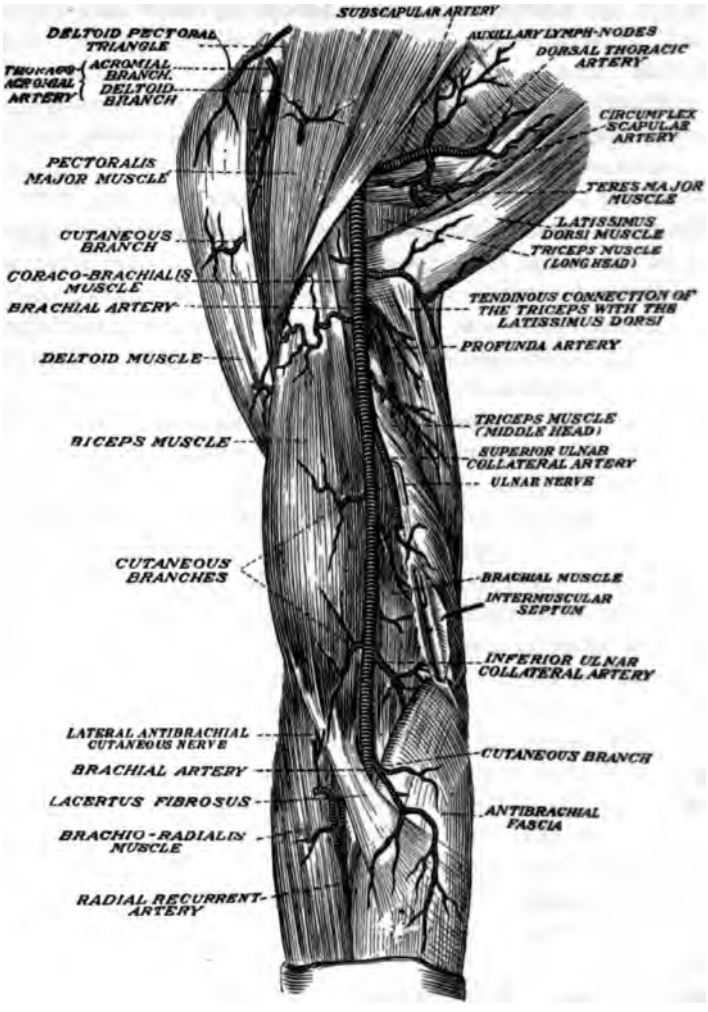


FIG. 1337.—(*Morris.*)

biceps, supra-spinatus, infra-spinatus, teres minor and major. The capsule of the shoulder-joint is of course opened. In the upper and outer part of the wound under the head of the humerus, lies the long head of the triceps; isolate and divide this carefully, avoiding injury to the circumflex nerve going to the deltoid. If part of the acromion process is to be preserved, divide it at the desired spot; if not, separate the soft structures from it and freely open the acromio-clavicular articulation.

Step 5.—Pass the finger under the trapezius muscle and treat it exactly as the deltoid was treated, *i.e.*, either divide it at its insertion along the upper edge of the spine of the scapula and reflect it upwards, or separate (by splitting) its clavicular from its scapular portions and, separating the latter from the chest-wall, divide it as near its origin as possible, leaving the muscle to be removed attached to the scapula.

Step 6.—At the upper border of the neck of the bone detach the omo-hyoid. Ligate and divide the supra-scapular (transverse scap.) artery (Fig. 1338).

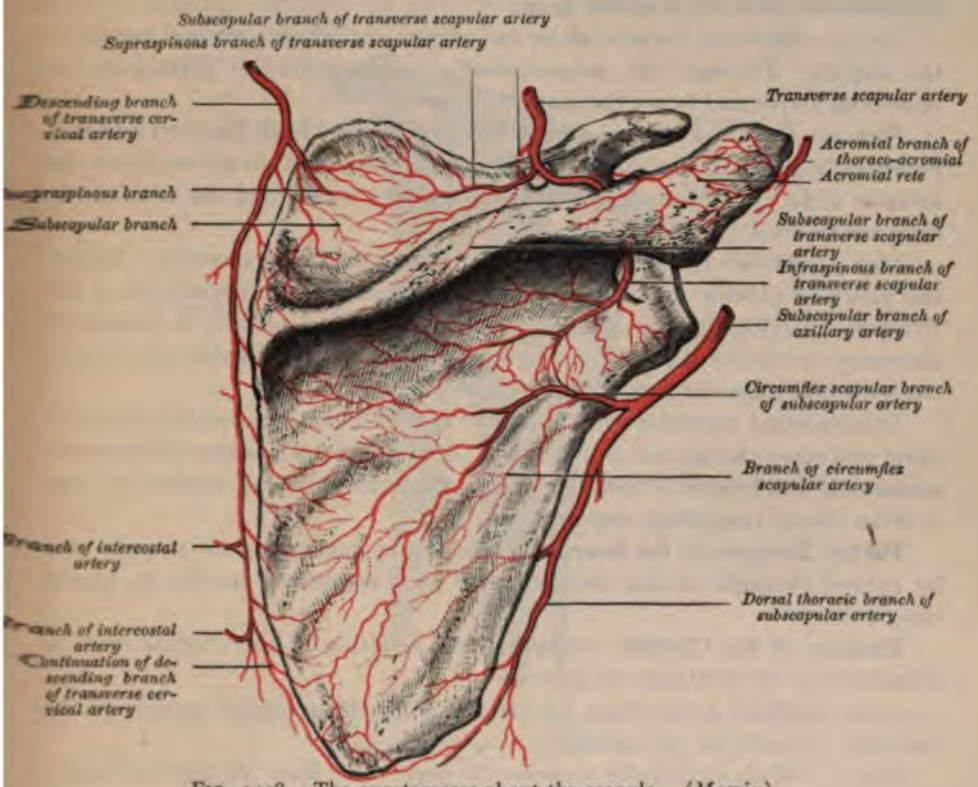

Subscapular branch of transverse scapular artery
Suprascapular branch of transverse scapular artery
Descending branch of transverse cervical artery
Infraspinous branch
Subscapular branch
Transverse scapular artery
Acromial branch of thoraco-acromial
Acromial rete
Subscapular branch of transverse scapular artery
Infraspinous branch of transverse scapular artery
Subscapular branch of axillary artery
Circumflex scapular branch of subscapular artery
Branch of circumflex scapular artery
Branch of intercostal artery
Dorsal thoracic branch of subscapular artery
Branch of intercostal artery
Continuation of descending branch of transverse cervical artery

FIG. 1338.—The anastomoses about the scapula. (*Morris.*)

Divide the levator anguli scapulæ at the upper angle of the bone and ligate and divide the posterior scapular (descending branch transverse cervical) artery. Divide the rhomboids and the serratus magnus.

Step 7.—Complete the division of the capsule of the shoulder-joint. The first step in the operation has attended to the freeing of the coracoid process and ligation of the subscapular artery. Remove the scapula.

Step 8.—Attend to hemostasis. Quénu unites the antero-inferior part of the capsule to the soft parts under the clavicle. With a wire suture he unites the upper part of the capsule to the scapula through which a hole is bored to receive the wire. The long head of the biceps is sutured in the same fashion to the clavicle. (If the scapular portion of the deltoid has been preserved, suture

its lower part, if possible, to the rhomboid; its u
Close the wound providing freely for drainage.

"The results are excellent; the patient retains
with the exception that he is unable to abduct the a
the trunk" (Burghard).

Subperiosteal Excision Scapula (Ollier).—Indi
ally osteomyelitis with its complications and seque

Step 1.—Make an incision down to the bone al
from the acromion to the vertebral border. With
the trapezius from the scapular spine.

Step 2.—Make an incision along and expose th
the scapula. Through this, subperiosteally, separ
bone both above and below the scapular spine.

Step 3.—Pull the vertebral edge of the scapula a
periosteally separate the subscapularis and all oth
anterior surface of the scapula—until the axillary
bone are reached.

Step 4.—Divide the acromio-clavicular joint fr
the articular capsule and the tendinous insertion
humerus. Divide the base of the coracoid proce
necessary to remove the head of the scapula it is
the bone and leave the articulating surface intact.

Subperiosteal resection when indicated is a mu
same procedure carried out on the normal cadaver
periosteum and loosens it from the bone. After sul
is often almost completely regenerated.

Partial Excision of the Scapula.—Almost any
be excised through suitable incisions, and such o
description.

Excision of the Clavicle.—Subperiosteal resect
demanded in the treatment of necrosis.

Step 1.—Make a cut along the clavicle from t
sternum. Divide the periosteum.

Step 2.—With an elevator separate the periostet
the bone. With a curved elevator (many elevator
which while blunted is still sharp enough to do d
end of the best elevator is more or less square wi
the bone separate the periosteum from the posteri
its middle.

Step 3.—(*a*) With Gigli's saw or bone forceps div
Grasp the end of the inner fragment with strong f
It is now easy to separate the fragment from the
blunt dissection aided by an occasional snip of the s
made to cut *against* the bone) and so to remove the
It is always best if possible to divide the bone near
to leave the articular end of the bone *in situ*. Do t
the bone. The insertion of the subclavius at the

middle thirds of the bone requires sharp division (always cutting on the bone). The coraco- and acromio-clavicular ligaments require division with knife or scissors, if the outer extremity of the bone is to be sacrificed, but it is always best to save the acromio-clavicular joint if possible.

(*b*) Instead of dividing the clavicle at its middle, divide it near its outer end or open the acromio-clavicular joint. Seize the outer mobilized end of the bone and pull it forwards. Separate the bone from the soft parts subperiosteally and remove it entire or in part.

Step 3.—Cleanse and close the wound, providing for very free drainage which is necessary because the operation is generally performed for necrosis.

FIG. 1339.—Outer view of the shoulder-joint, showing the coraco-humeral and transverse humeral ligaments. (*Morris.*)

Excision of Clavicle for Sarcoma.—*Step* 1.—Make an incision through the skin alone along the whole length of the bone. Supplement this cut by vertical ones, if required for the reflection of the skin from over the whole of the tissues to be removed.

Step 2.—Expose the outer edge of the clavicular insertion of the sterno-mastoid. Pass a finger or director (the author for such purposes used a closed blunt-pointed scissors curved on the flat) behind the clavicular portion of the muscle and divide it at a safe distance from the disease. Expose the inner edge of the clavicular insertion of the trapezius and divide it in the same manner. In the same fashion divide such portions of the pectoralis major and the deltoid as are attached to the clavicle.

Step 3.—Mobilize the acromial end of the bone by dividing the acromio and coraco-clavicular ligaments. This is a difficult step (Fig. 1339). Pull the outer

end of the clavicle forwards. Remember the subclavian vein which is separated from the bone by the subclavius muscle. Separate the bone and tumor up to the claviculo-sternal articulation. Disarticulate.

Step 4.—Attend to hemostasis. Close the wound. Dress. Treat like a fracture of clavicle.

The results as regards use of the arm, strange to say, are reported to be most excellent.

Excision of the Clavicle with Repair by Bone Transplantation.—After excising the clavicle in whole or in part the defect may be repaired by transplanting a suitable segment of bone, preferably from the patient himself. Bone may be obtained easily from the tibia. Witzel (Molineus, Deutsche Zeitsch. f. Chir., cxxi, 180) in two cases excised the outer two-thirds or more of the clavicle and filled the osseuos defect by transplantating the spine of the scapula. The spine of the scapula and the clavicle were exposed by an incision beginning one hand's breadth from the vertebral column and running outwards along the spine of the scapula to be continued anteriorly two fingers' breadths below the parallel to the clavicle. The epaulet like flap outlined by the incision was reflected upwards, the clavicular insertions of the pectoralis major and deltoid were divided, the acromio-clavicular joint opened and the diseased portion of clavicle removed. After separating the supra- and infra-spinati from the scapular spine, the latter was cut away from the scapula with a chisel. (At the median or vertebral end it may be necessary to remove a portion of the body of the scapula along with its spine). It was now easy to swing the mobilized bone forwards and to unite it with the stump of clavicle by a wire suture. After 4 weeks, passive motion was begun and in 8 weeks there was almost perfect function.

Presternal Dislocation of the Clavicle.—Grunert ("Med. Klinik," May 29, 1910) recommends, in presternal dislocation of the clavicle, that the meniscus of the sterno-clavicular joint be excised and the bones united by three sutures.

CHAPTER XCII

SHOULDER

Intra-articular injections for the introduction of iodoform emulsion or Murphy's formalin glycerine. Introduce the trocar either just external to the coracoid process or external to the angle of the acromion (*i.e.*, the angle formed by the junction of the scapular spine and the acromion process). Push the trocar into the prominence formed by the swelling of the joint capsule.

Arthrotomy for Drainage.—It is usually recommended to open the joint by an anterior vertical incision as in arthrectomy but drainage through such a cut is not efficient and a counter opening is usually required. The following operation is entirely preferable:

Beginning at the posterior prominence or angle of the acromion process make an incision downwards along the posterior border of the deltoid for about 2 inches. This opens the subdeltoid bursa. Retract the edges of the wound and expose the joint capsule crossed by the tendons of the infra-

spinatus and teres minor. Incise the capsule. Explore the joint lest resection should be demanded. Drain.

Ollier's Operation or Subperiosteal Resection.—*Step* 1.—Abduct the arm moderately and have an assistant hold it steadily. From a point ½ inch below the clavicle and beside the coracoid process make an incision 4½ to 5 inches in length, which is directed downwards and outwards towards the insertion of the deltoid (Fig. 1340). The incision divides the skin and subcutaneous tissues. Distinguish the anterior or internal (pectoro-deltoid groove) border of the deltoid. Incise the deltoid a little to the outside of, and parallel to its internal margin, thus avoiding injury to the cephalic vein and a large branch of the acromio-thoracic artery. Retract the outer side of the wound (skin and deltoid), thus exposing the head of the humerus.

Step 2.—Rotate the arms so as to make out the bicipital groove. Incise the joint capsule throughout its whole extent parallel and external to the tendon of the biceps. Do *not* injure the acromio-coracoid ligament. Prolong the capsular incision downwards on the humerus, dividing the periosteum, to the point where it is desired to sever the bone (Fig. 1341). Introduce a *sharp* but not pointed periosteal elevator and separate the periosteum and tendinous insertions, on the outer side of the wound, from the external or greater tuberosity.

FIG. 1340.—Arthrotomy.

FIG. 1341.—Excision of shoulder. (*Schwartz.*)

As the separation progresses the assistant rotates the humerus inwards. In using the sharp elevator keep the edge of the instrument firmly pressed against the bone, and when there is danger of tearing the periosteum endeavor to sacrifice bone rather than impair the integrity of its fibrous covering. If these rules are observed, the tendinous insertions and periosteum will be raised from the bone together and remain attached to the fibrous capsule of the joint. One is rarely completely successful in this, but even partial success is benefical. The external tuberosity having been denuded, open the sheath of the biceps tendon, lift the tendon from its groove and retract it inwards. Separate the periosteum and tendinous insertions from the internal or lesser tuberosity in the manner already described, while doing so have the assistant rotate the arm outwards. Make the head of the humerus protrude into the wound by carrying the elbow backwards and upwards. Separate the posterior and lateral fibrous attachments from the bone by the method already described (Fig. 1342).

Step 3.—Examine the head of the bone and make it protrude out of the wound (Fig. 1343). Saw off as much of the upper end of the humerus as is rendered necessary by the presence of disease.

Step 4.—Examine the glenoid cavity and if disease is present remove it with a sharp spoon, chisel, or rongeur forceps.

Step 5.—With forceps and scissors dissect away all diseased synovialis. The walls of all sinuses must be removed by dissection or by curettement.

Step 6.—Provide for posterior tubular drainage by an incision in an appropriate position behind. Rub the wound with iodoform. Provide for drainage of anterior wound and partially close it with sutures. Apply dressings. A large pad must be placed in the axilla to keep the upper end of the humerus from falling inwards and the elbow and forearm bandaged to the chest. As soon as the wound has healed, the tone of the shoulder muscles may be kept up

FIG. 1342.

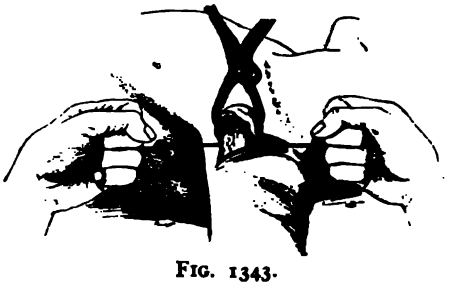


FIG. 1343.

FIGS. 1342 AND 1343.—Excision of shoulder. (*Schwartz.*)

by applications of electricity. No passive movements or massage must be attempted before the lapse of about eight weeks and the movements of abduction must be the last to be used. The reason for delaying movement is that one must wait until the upper end of the humerus has become to some extent fixed in its new position and thus avoid an undersirable "flail-joint."

In some cases where the tissues have not been softened by inflammation it is very difficult to detach the periosteum and tendinous insertions from the major and minor tuberosities of the humerus. After this feat has been attempted the detached periosteum is usually a thing of "shreds and patches." In the case of the hip- and ankle-joints König has overcome this difficulty by chiseling off from the main bone a shell of bone and retracting it along with its periosteal and tendinous attachments. The method has many good features in addition to its simplicity that the author has applied to the shoulder-joint.

Expose the shoulder through the Ollier incision. Divide the periosteum of the humerus along the outer edge of the bicipital groove. Place a chisel in position with its edge against the outer margin of the bicipital groove and cut through the great tuberosity (Fig. 1344). Reflect the detached shell of bone with all its connections outwards. Lift the long tendon of the biceps outwards.

ith the chisel cut the lesser tuberosity free from the shaft of the humerus. eflect inwards the shell of bone, with its periosteal connections and with the ng head of the biceps. Dislocate the head of the humerus into the wound, the same time severing its posterior attachments with periosteal elevator or issors as already described.

FIG. 1344.—Author's method of excision of shoulder.
External shell of bone (major tuberosity held outwards by chisel); B. Internal shell of bone retracted inwards; C. Bicipital groove.

After the active operation is completed, examine the shells of bone which main attached to the periosteum. If they show evidences of disease, remove em; if not, replace them. When the shells of bone are replaced, arrange them such a manner that the long tendon of the biceps will remain superficial to em.

W. T. Reynold's showed the author a method (which was apparently devised A. W. McArthur) for exposing the shoulder through the axilla. From a int a short distance below the coracoid process make an incision downwards d slightly outwards until the lower edge of the anterior axillary fold is divided

and the pectoralis major is exposed. Divide the pectoral
to its fibres and about 1½ inches from its insertion. Thi
to the shoulder joint. After completing whatever proc
the bones or joint, suture the divided muscle carefully
Good function of the shoulder may be expected.

Atypical Resection of the Shoulder.—In children it
to avoid typical resection of the upper end of the hume
or destruction of the epiphyseal cartilage leads to non-dev
arm. In suitable cases one can expose the joint by the (
the head of the humerus and the glenoid cavity and with
remove any osteal foci of disease which may be found.
ment are the same as in the case of the knee-joint.

Resection of the Shoulder from Behind (Kocher)
cavity is much diseased or the arthritis is very diffuse, th

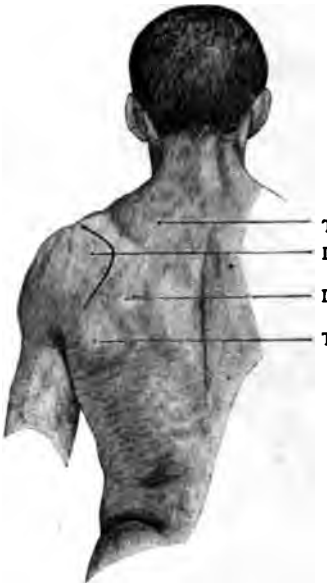


FIG. 1345.—Kocher's incision. (*Kocher.*)

do not give sufficiently free access to the joint. For th
devised the following operation:

Step 1.—Beginning at the acromio-clavicular joint, n
the upper margin of the spine of the scapula to about th
from this point continue the incision in a curve downw
about two fingers' breadth from the posterior axillary fol

Step 2.—Open the acromio-clavicular joint. Divide
trapezius into the spine of the scapula throughout the
Expose the posterior margin of the deltoid, push the fin
and separate it from the underlying infra-spinatus. Di
origin of the deltoid posteriorly (Fig. 1346). Push the
surface of the spine of the scapula, between the deltoid

to the place where the infra-spinatus loses touch with the spine. Bluntly push the supra-spinatus away from the upper surface of the spine until the finger can be hooked round the outer end of the spine.

Step 3.—**Method A.**—With a chisel make an oblique section of the spine of the scapula, so that the acromion process and the whole crest of the scapular spine from which the deltoid arises are separated from the body of the bone. Before dividing the bone it may be well to drill holes in the bone on each side of the line of section so as to be able conveniently to wire the fragments on completion of the operation. Instead of boring holes, one may subperiosteally resect a small fragment of bone on each side of the line of section, thus leaving

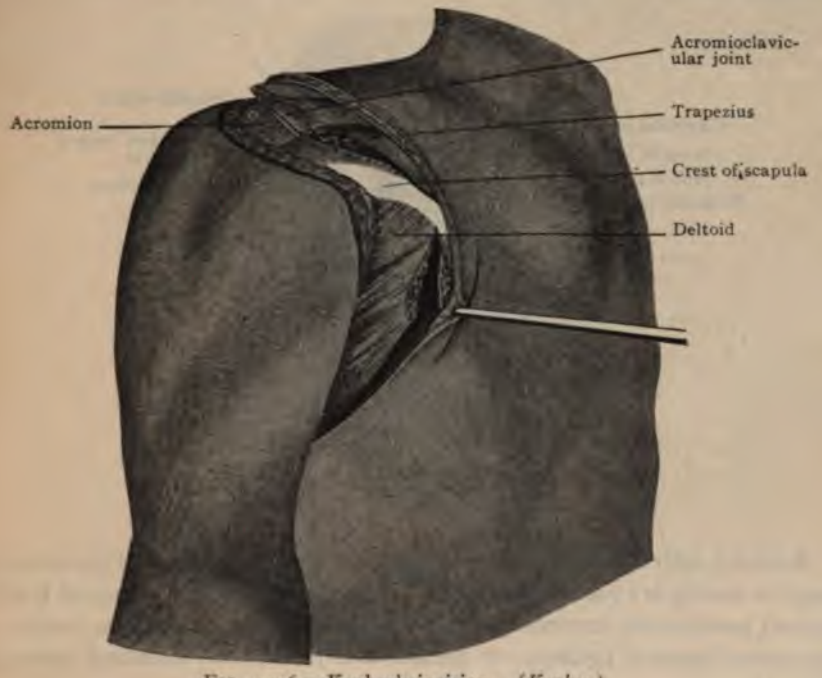


FIG. 1346.—Kocher's incision. (*Kocher.*)

small flaps or tags of periosteum which may be sutured together. In dividing the bone be careful not to injure the supra-scapular nerve as it goes through the great scapular notch.

Method B.—Instead of cutting off the mass of the spine of the scapula, merely cut off, subcortically, that portion from which the deltoid arises.

Step 4.—Turn downwards the flap of deltoid muscle with its bony attachments (Fig. 1347). This exposes very freely the outer and posterior surfaces of the head of the humerus with the attachments. Rotate the arm outwards. Make a longitudinal incision down to the bone along the posterior margin of the bicipital groove and expose the biceps tendon up to its origin above the glenoid cavity.

Step 5.—Beginning at the posterior margin of the bicipital groove, separate the periosteum, and with it the external rotators of the humerus from the greater

tuberosity, and retract these structures backwards. Inspect the biceps tendon and its sheath. Retract the tendon forwards. By flexing the elbow, rotating the shoulder, pushing the head through the wound, etc., etc., it is now possible to inspect the whole joint and judge if it is necessary to resect the joint or if a mere arthrotomy will suffice.

If arthrectomy is necessary proceed to—

Step 6.—Subperiosteally separate the insertions of the muscle from the lesser tuberosity forwards and inwards. Complete the resection, removing all diseased tissue.

Step 7.—Replace the deltoid flap and fix it in position by sutures. Provide drainage. Dress.

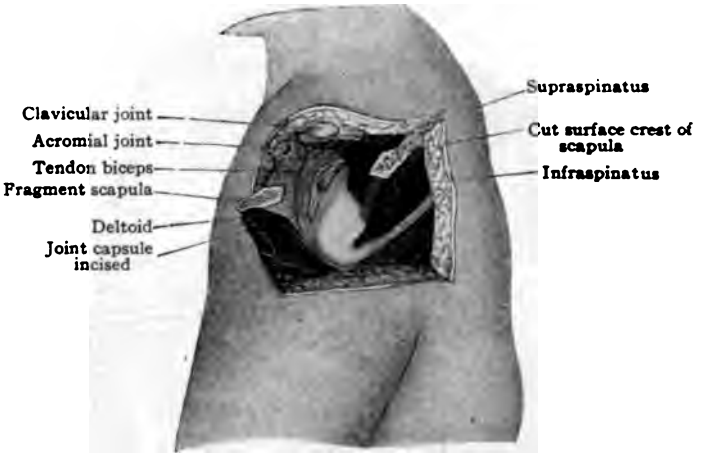


FIG. 1347.—Kocher's operation. (*Kocher.*)

Kocher's operation sounds formidable, but innervation is well preserved and the after-results are remarkably good. If partial resection is sufficient Kocher's method permits the anterior part of the capsule, the subscapular muscle and the coraco-humeral ligament to remain uninjured, thus avoiding subsequent dislocation.

Excision Shoulder.—A rational method of resection must comply with the following conditions: Catterina ("Zentralblatt für Chir," 1906, No. 2).

1. It must be safe and must hazard no important structures.
2. It must be easy.
3. It must afford a good view of all parts of the joint cavity.
4. It must be suitable to all cases requiring resection.

Catterina endeavors to fulfil these requirements by temporary resection of the outer third of the clavicle, thus obtaining free exposure of the joint and avoiding injury to the deltoid and to the circumflex nerve. The method is suitable to all cases, especially to those of old anterior dislocations requiring reduction or excision.

Step 1.—From a point about 2 inches above the junction of the middle and outer thirds of the clavicle make an incision downwards and outwards through the skin and fascia for about 6 inches along the groove between the pectoralis

major and the deltoid. Retract, or doubly ligate and divide, the cephalic vein.

Step 2.—At the junction of its middle and outer thirds separate the soft parts from the clavicle sufficiently to bore two holes through the bone about ¾ inch apart. Midway between these two holes (which will serve for future wiring) divide the bone with Gigli wire saw.

Step 3.—Rotate the external portion of the clavicle outwards and divide its connections with the trapezius, the subclavius, and the coraco-clavicular ligament. Leave the clavicular origin of the deltoid intact (Fig. 1348).

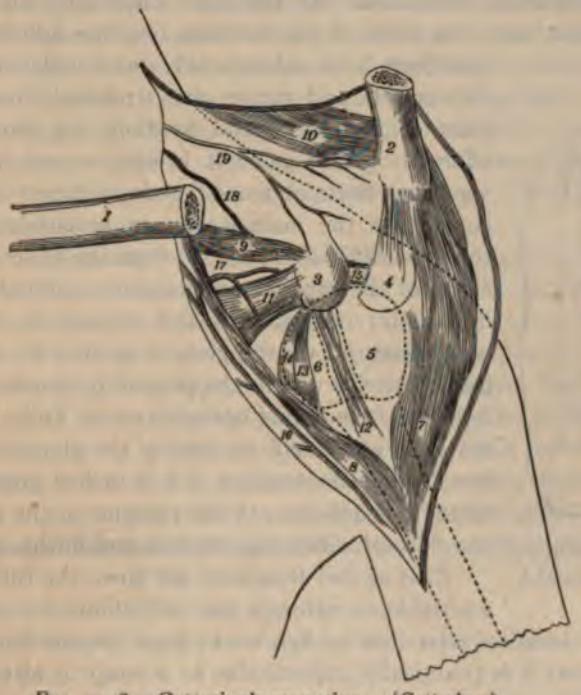


FIG. 1348.—Catterina's operation. (*Catterina.*)

1. Clavicle. 2. External third clavicle. 3. Coracoid. 4. Acromion. 5. Great tuberosity humerus. 6. Lesser tuberosity humerus. 7. Clav. portion deltoid. 8. Pectoralis major. 8. Subclavius. 10. Trapezius. 11. Pectoralis minor. 12. Long head biceps. 13. Short head biceps. 14. Coraco-brachialis 15. Coraco-acromial ligament. 16. Cephalic vein. 17. Thoracico-acrom. art. 18. Suprascap. nerve. 19. Suprascap. art.

Step 4.—Reflect the flap consisting of bone, deltoid, etc., outwards and backwards so as to expose the joint fully.

Step 5.—Treat the joint *secundum artem.*

Step 6.—Replace the flap. Wire the clavicle. Close the wound after providing for drainage.

The head of the scapula is diseased or injured, the head of the humerus is unaffected. Resection is required. v. Esmarch operates as follows:

1. Make a curved incision around the posterior margin of the acromion and divide the fibres of the deltoid there inserted (Fig. 1349). Expose the posterior and upper surface of the joint capsule.

2. From the middle of the incision cut with a knife down to the postero-superior margin in the head of the scapula, make a longitudinal incision through the joint capsule between the tendons of the supra- and infra-spinatus to the middle of the greater tuberosity. This cut divides the skin and the deltoid (in the direction of its fibres).

3. Retract the soft parts. With a periosteal elevator separate the long head of the biceps, the articular capsule and the periosteum all together from the neck of the scapula. With a finger saw divide the neck of the scapula and remove the glenoid cavity.

4. Close the wound after providing drainage.

When a shoulder dislocation has remained unreduced for even a comparatively short time, the head of the humerus becomes adherent to its surroundings. In subcoracoid and subglenoid dislocations the vessels and nerves are stretched directly over the head of the bone, and as they are liable to become adherent to the bone it is easy to see how dangerous vigorous efforts at manual reduction may become. This constitutes the main *danger* in manipulative reduction, the main *difficulties* arise (*a*) from the adhesions; (*b*) shortening of the muscles and tendons inserted in the tuberosities; (*c*) contractions and alterations of the capsule which may fill up the glenoid cavity; (*d*) changes in the glenoid cavity due to chipping of its border and such like lesions; (*e*) in a case operated on by Tully Vaughan bony material was found occupying the glenoid cavity. This bony material consisted of a detached greater tuberosity which was adherent to the margins of the glenoid cavity, the floor of which was smooth and unchanged.

FIG. 1349.—Esmarch's incision. (*Esmarch.*)

Cheyne and Burghard lay down the rule that it is not advisable to attempt the reduction of a subcoracoid or subglenoid dislocation after four or five weeks have elapsed from the time of injury, and that it is practically unjustifiable to attempt it after seven weeks. Even within the period mentioned any attemps at reduction must be made with extreme care, as rupture of the axillary artery has resulted from attempts to reduce a dislocation of four weeks' standing.

Operations for reducing (so-called irreducible) dislocations of the shoulder may be roughly classified as follows:

I. Subcutaneous myotomy or tenotomy.

II. Osteotomy.

III. Arthrotomy or arthrotomy plus resection.

Subcutaneous Myotomy and Tenotomy.—The few cases of reduction after the subcutaneous division of obstructing bands seems to have been uniformly successful. [Unsuccessful operations have probably escaped publication.]

Weinhold (1818) divided the pectoralis major; Dieffenbach divided the pectoralis major, latissimus dorsi, teres major and minor, and even some of the ligaments; Simon obtained recovery after seventy successive operations on one patient. Polaillon operates as follows: Introduce a sharp-pointed teno-

tome horizontally from without inwards to the head of the humerus at a point one centimeter below the tip of the acromion. Guided by this instrument introduce a long probe-pointed tenotome until it penetrates between the anterior surface of the head of the humerus and the deltoid. Remove the sharp-pointed instrument. Cutting against the bone divide all obstructing fibrous tissues. Partially withdraw the tenotome; reintroduce it behind the head of the humerus and with the same precautions divide all obstructing fibrous bands there situated. In similar fashion divide obstructing bands in any position around the upper end of the humerus. Delay efforts at reduction for a few days until the tenotomy wound has healed. Mollière operates very similarly, but proceeds to manipulative reduction as soon as the tenotome is removed. Forgue and Reclus recommend subcutaneous operation because of its ease and safety. Cahier considers that the operation possesses all the disadvantages of work done in the dark, viz., dangers to nerves, vessels, and to the long head of the biceps, that it only incompletely divides obstructing bands and that it pays no attention to the fragments of bone torn from the greater tuberosity (when that is fractured) and remaining attached to various tendons. Most surgeons will agree with Cahier in these conclusions.

Osteotomy of Humerus for Irreducible Dislocation.—In one case J. Ewings Mears performed subcutaneous osteotomy for old subcoracoid dislocation. At first the result was good, later callus, etc., impaired the usefulness of the limb. In cases where there are no serious pressure symptoms and owing to age, debility, etc., the patient is unsuited to a long operation, Souchon proposes to resect one inch of the shaft of the humerus where it joins the head and place the resected extremity in or near the glenoid cavity. This leaves the head in abnormal position, but, as already noticed, the head is causing no serious pressure symptoms and the patient is unfit for more serious interference.

Arthrotomy for Unreduced Subglenoid or Subcoracoid Dislocation of the Shoulder.

1. Open the joint by Ollier's anterior incision.

2. Retract the deltoid outwards, the pectoralis major inwards. This exposes the head of the bone.

3. Examine the position of the vessels and nerves; note if they adhere to the bone; avoid injuring these structures. Examine the anatomical neck of the bone; divide the fibrous structures adherent to it, with a periosteal elevator detach them from the head and neck of the bone; keep the instrument *against* the bone during this work so as not to injure the vessels and nerves.

4. Apply extension to the arm. With the finger feel for bands obstructing reduction; divide such.

5. Examine the glenoid cavity. If it is filled with fibrous tissue, clear such away by dissection. If the capsule is in fair condition, preserve it; if it hinders reduction, divide it, and after reduction repair it by sutures. If the capsule is in bad condition, *i.e.*, contracted and distorted, dissect it away.

6. Try to reduce the dislocation. This is usually possible. If, however, reduction is still impossible examine with the finger for the obstruction. The obstruction is commonly muscular (supra and infraspinatus). Very gradually separate these muscles at their insertion into the great tuberosity. Do not

separate them one iota more than is necessary for reduction. Separation of the subscapularis from the lesser tuberosity is to be avoided if possible. Complete the reduction.

7. If sufficient capsule remains, repair it by sutures. With sutures restore the soft parts, both deep and superficial, as nearly as possible to their normal condition. Close the wound with or without drainage. Dress. Keep the

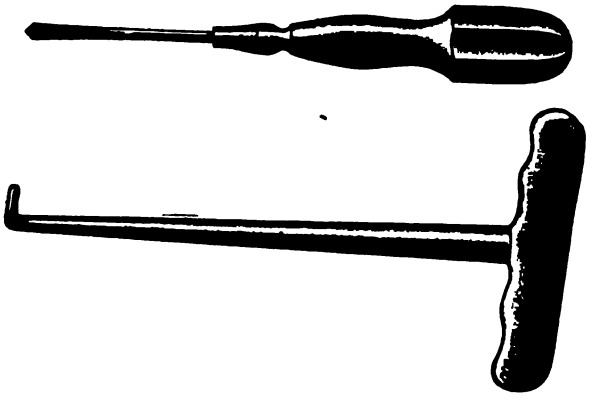


FIG. 1350.—(*McBurney.*)

arm bound to the side until healing is complete. Begin passive motion early, using an anesthetic if necessary.

The operation is more complex when there is fracture of the neck of the bone as well as dislocation of the head. If the head of the bone is seemingly sufficiently nourished reduction must be attempted by pushing and prying the head of the bone with elevators, forceps, and McBurney's ingenious hook (Figs. 1350 and 1351). Free division of resisting bands is of course necessary.

FIG. 1351.—(*McBurney.*)

After successful reduction, the fractured bones must be united by suture (wire, chromicized catgut) or by buried metallic splinting. In fracture-dislocation of the humerus operation may be performed immediately, *i.e.*, before the lymphatics have become clogged with débris in process of removal, or late, *i.e.*, after the lymphatics have removed the débris of destroyed tissues and effused blood and before real attempts at repair [illegible] have begun.

As after-treatment [illegible] motion [illegible] run early (about the tenth day).

Instead of exposing the joint by means of Ollier's incision Catterina's method ıay be used.

Dollinger ("Zentralblatt für Chir.," Dec. 6, 1902) in seven cases found

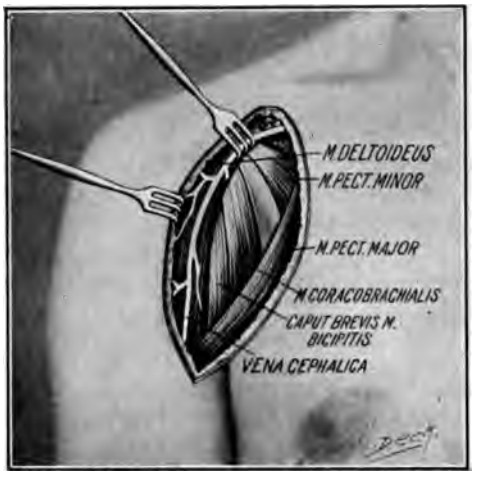


FIG. 1352.—Old dislocation of shoulder. (*Dollinger.*)

ımarkable absence of callus, scar tissue, etc. He operated with excellent ısults in the following manner:

Step 1.—Incise from the clavicle to the insertion of the pectoralis major ong the inner side of the cephalic vein. Penetrate the cleft between the del- ıid and the pectoralis major and expose the coracoid process (Fig. 1352).

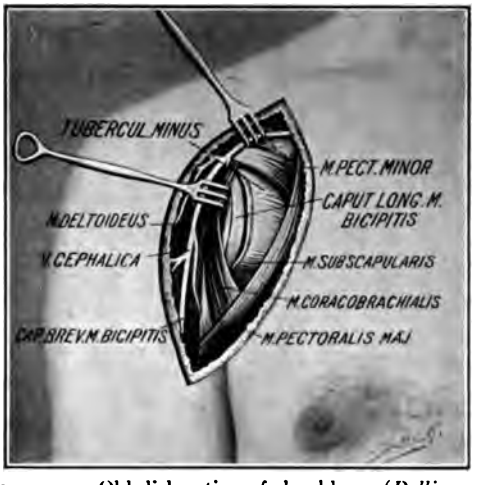


FIG. 1353.—Old dislocation of shoulder. (*Dollinger.*)

Step 2.—Retract the pectoralis minor up, the coraco-brachialis out, and the [redacted]toralis major inwards. Expose the bicipital groove and lesser tuberosity. [redacted]jure the long head of the biceps. The humeral head lies posteriorly [redacted]omewhat inwards (Fig. 1353).

Step 3.—Rotate the upper arm outwards, thus bringing into the wound subscapular and the head of the humerus covered by it (Fig. 1354).

Step 4.—Divide the tendon of the subscapularis and expose the head of humerus (Fig. 1355). It is possible to rotate the bone outwards to any ex

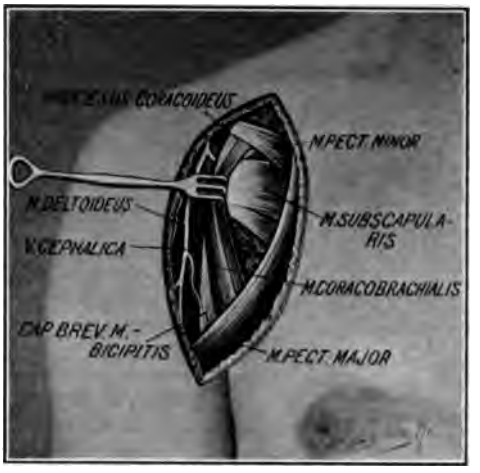


FIG. 1354.—Old dislocation of shoulder. (*Dollinger.*)

required and so Kocher's method of manipulative reduction becomes ea According to Dollinger, the retracted and perhaps sclerosed subscapul forms the obstacle to reduction in uncomplicated cases and under it lies the h of the humerus in subcoracoid dislocation. If, as happened in one of Dolling

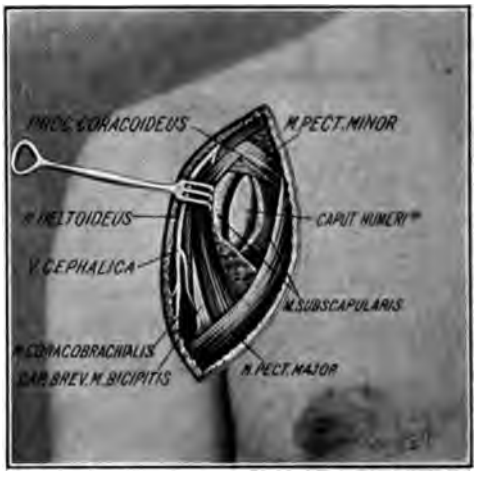


FIG. 1355.—Old dislocation of shoulder. (*Dollinger.*)

cases, reduction is impossible after section of the subscapular tendon, pull t arm strongly downwards, continue the split in the tendon to the glenoid fo and remove any obstruction present. Sometimes reduction by arthrato roves impossible. Under these circumstances decapitation of the humer

nd removal of the head is proper, unless a new joint has formed giving satis-
ictory function. Usually there is great pain and disturbance due to pressure
n the vessels and nerves. The operation is essentially the same as that for
eduction of the dislocation, but the head of the bone is removed after section of
ts neck by means of a Gigli wire saw. Enough bone must be removed to insure
good new joint. As an aid to the making of a new joint one may cover the
ivided end of the humerus with the flap of muscle or, better, of fascia and fat.

Regarding excision, Jonas writes: "This is an operation to be avoided when possible, on account of the resultant flail-like condition of the arm and yet must be done (*a*) when the humeral head and neck become too extensively stripped of their attachments, experience having shown that necrosis may occur in 16 per cent. (Souchon) of the cases; (*b*) when osseous union has occurred between

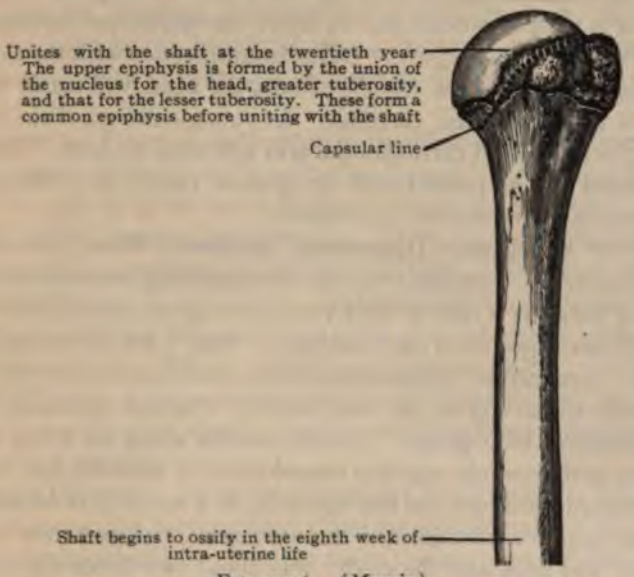

Unites with the shaft at the twentieth year
The upper epiphysis is formed by the union of the nucleus for the head, greater tuberosity, and that for the lesser tuberosity. These form a common epiphysis before uniting with the shaft
Capsular line
Shaft begins to ossify in the eighth week of intra-uterine life

FIG. 1356.—(*Morris.*)
Ossification of the humerus; the figure also shows the relations of the epiphyseal and capsular lines.

the head and the ribs; (*c*) when, after a division of all the restraining soft parts, the head rests against the point of the acromion process" ("Annals Surg.," May, 1903).

In case of osseous union between the head of the humerus and the ribs it would seem to the author better when possible to divide this union, trim away irregularities from the head of the bone, cover it with a pedunculated flap of fat and fascia and reduce it, thus forming a new joint with the minimum loss of substance.

In his classical paper on irreducible shoulder dislocations ("Transactions Am. Surg. Assoc.," 1897) Souchon comes to the following conclusions regarding anterior displacements: "The anterior incision is the route. Reduction is the more desirable operation, because it preserves the head and all the movements depending thereon. Reduction should be done only in cases where the head and glenoid cavity are in good condition; when no extensive dissections have to

be made; when it is easily effected without any great effort; when the head does not need to be trimmed or the cup to be too deeply scooped or enlarged; when the head readily remains in place, but not too tightly. All this regardless of the time or standing of the dislocation. It should, however, always be attempted conscientiously, because many have resected, perhaps, when the dislocation could have been reduced. Disregard of these rules may result in necrosis of head, in recurrence of the dislocation or in anchylosis, with their inevitable consequences. Resections should be practised in all other cases. When in doubt it is preferable to resect. How much to resect, *i.e.*, whether to saw, through the anatomical neck, or obliquely and downwards outside the tuberosity, or horizontally on a level with the lower margin of the head, must be determined in each case; it is best to remove too much than too little." The last remarks of Souchon require some modification. In subjects under eighteen years of age it is most important not to injure the epiphyseal cartilage between the head and the shaft (Fig. 1356). "A horizontal section with the saw, starting at the internal insertion of the capsule around the head, will surely carry away the totality of the conjugating cartilage. In young children, if the resection is made below the epiphyseal cartilage, the arm will cease to grow. The resected extremity should not be pushed into the glenoid cavity in children, lest the growth of bone cause anchylosis" (Souchon).

Posterior or Subspinous Dislocation Shoulder.—These dislocations are commonly congenital. Scudder's rule for distinguishing between the congenital and traumatic varieties is that in the former the scapula, clavicle and arm bones are not so well developed as on the sound side. Only a few operations have been performed for "irreducible" dislocations of the above kind and of these Phelps's operation seems to have given the best results. Phelps's operation is thus described in Souchon's monograph: "Curved incision along the lower edge of the deltoid and on to the scapula, and flap turned down; it would be best to curve the incision downwards and turn the flap upwards, as it would give better drainage.

Difficulties and complications of the operation: The posterior edge of the glenoid cavity was gone and the cavity was about two-thirds the normal size; a portion of the head of the humerus was cut away in order to fit it to the socket; also cut away a portion of the redundant capsule posteriorly; the bone replaced and a stitch put in behind to help retain the head in place.

Complications after the operation: None. Result immediate: Drainage-tube left a week. Result remote: Is satisfactory. Dr. A. P. Dudley saw the patient a year after the operation, and there was a little difference between the two arms. Remarks: Dr. Dudley did not doubt that the injury had occurred during delivery. Doctors who had seen the patient before were of the opinion that it was one of paralysis. Dr. A. M. Phelps says that the method promised success during the first year, although one case has been operated in which it was successful at the fifth year."

In another case in which reaction of degeneration was present, apparently due to pressure neurosis, the result obtained by Phelps was not so perfect, but the reaction of degeneration disappeared.

Peckham ("Am. Journ. Orthopedic Surg.," April, 1905) reports two cases in which he obtained improvement by means of Phelps's procedure.

Dislocation plus Fracture of the Head of the Humerus.—In 117 cases of the above injury the fracture was located at the surgical neck in sixty-nine, at the anatomical neck in twenty-seven, at the "neck" in eleven, at both surgical and anatomical necks in six; one case was comminuted, and the "upper part" of the humerus was fractured in three (McBurney and Dowd). In the aged, the feeble, and perhaps in diabetics and some nephritics, etc., it is wise to adopt Riberi's treatment *provided* that the head of the bone is not giving rise to pain and other pressure symptoms. This treatment (Riberi's) consists of massage and passive, later, active motion, and aims at the production of a pseudarthrosis. In all other cases more active treatment is necessary. Never fail in recent cases to attempt reduction, under an anesthetic, by means of manipulation and finger pressure applied to the dislocated head of the humerus. This is occasionally successful and the condition becomes one of mere fracture. Never attempt reduction by any of the manipulations suitable in uncomplicated dislocation. It is wise to be prepared to proceed at once to arthrotomy if simpler means fail.

Arthrotomy for Fracture-dislocation of the Humerus.—McBurney's Operation.—Make an incision about 1½ inches long about 1 inch below the acromion. Penetrate the deltoid to the outer surface of the upper fragment. Drill a hole through the upper fragment horizontally. (This supposes fracture at or near the surgical neck.) Into the perforation fit the right-angled beak of McBurney's traction hook (Figs. 1350 and 1351). Make traction on the upper fragment by means of the hook and at the same time press with the fingers on the head of the bone and so reduce it. Treat the fracture *secundum artem*. Farquhar Curtis has found McBurney's hook tear out during the necessary traction but by using leverage with a periosteal elevator and by dividing obstructing bands he succeeded in obtaining reduction.

Schlange's Operation.—("Archiv für klin. Chir.," lxxxi, II, Theil). Abduct the arm. Make a 4½ inch incision along the axillary margin of the pectoralis major and coraco-brachialis. Retract these two muscles forwards, retract the axillary vessels and nerves backwards and protect them. Incise the joint capsule or enlarge (if necessary) any tear which may involve the capsule and so expose the heads of the bone. Remove any splintered fragments of bone. Reduce the dislocated humeral head by direct manipulation with the fingers and by prying with blunt instruments. Schlange operated in this manner on one case of fracture of the anatomical and in one of the surgical neck. In the former case the question of resection presented, as the head of the bone was separated from almost all its connections; "the good result obtained demonstrates that one dare to and ought to act very conservatively just as in the case of a dislocated astragalus." This advice of Schlange's is good when the patient is in the hands of a first-class surgeon and in proper surroundings, but there are circumstances in which resection is much safer and will give an excellent functional result, especially if the upper end of the humerus be covered with Murphy's flap of fatty fibrous tissue.

Codman's (Sabre-cut) **method** of exposing the shoulder is described on p. 1108.

Arthrodesis Shoulder.—When, as a result of paralysis, the shoulder-joint becomes flail-like and yet the muscles of the elbow and of the hand and those

uniting the scapula to the trunk are not paralyzed, the operation of arthrod may be useful. If the elbow muscles are also paralyzed but those for the h remain active, artificially produced anchylosis (arthrodesis) of both shoulder elbow may be of service.

Step 1.—Exposure of the joint. Owing to the degeneration of the del and of the circumflex nerve in cases of paralytic luxation it is useless to much attention to these structures, hence incision may be made where venient ("Bothezat, Rev. de Chir.," June, 1901).

From a point a little internal to the acromio-clavicular joint make an inci downwards to the outer side of the pectoro-deltoid groove for a distance of 1¼ 4 inches.

Step 2.—The deltoid being practically absent, it is very easy to open joint by cutting the capsule along the bicipital groove.

Step 3.—Excise as much of the synovialis as possible and scrape with spoon every accessible part of the remainder.

Step 4.—Push the head of the humerus out of the wound. This is e because all the tissues are relaxed and the muscles paralyzed. Remove cartilage from the head of the bone. Vivify the glenoid cavity by removing cartilage. Vivify an appropriate surface of the acromion process.

Step 5.—Let an assistant steady the scapula in good position. Place humeral head in contact with the glenoid cavity and the acromion proc The most useful position (Bothezat) is one of slight internal rotation with arm at an angle of 45° to the external border of the scapula. Fix the bon position by means of two wires, one uniting the humerus to the upper part of glenoid, the other uniting the humerus to the acromion.

Step 6.—Close the wound by deep and superficial sutures, being car to "take up the slack" in the capsule. Immobilize. After the wound completely healed treat the muscles by means of massage and electrical stir lation, but keep up immobilization for two months, *i.e.*, until consolidation had time to take place.

Habitual Dislocation Shoulder.—Burrell operates by excising a portion the capsule in the following manner:

Make Ollier's anterior incision.

Expose the coraco-brachialis, short head of the biceps, and upper part of tendon of the pectoralis major below; divide the upper three-fourths of tendon of the pectoralis major at its insertion and so expose the head of humerus and part of its shaft.

Rotate the arm outwards and push the elbow a little backwards, expos the tendon of the subscapularis stretched over the head of the bone. Div the upper portion of this tendon. Abduct the arm to an angle of 45°; press head of the bone backwards so as to relax the capsule anteriorly. Excise a st of capsule about ¾ inch long by ⅜ inch wide. Suture the wound in the capsu Close the wound. Dress. Immobilize. A. I. Mackinnon improves Burre operation by avoiding excision of the capsule and by closing the wound in overlapping fashion. The operation consists "in doing an open arthrotomy; muscles are well retracted and the capsule is opened from the coracoid proc downwards. Mattress sutures are introduced 1 to 1½ inches from one mar

of the incision in such a manner that when they are tied one flap slides under the other. By this process there is a double layer of capsule over what is ordinarily the weakest point, and increased protection against recurrence is given the joint. A running suture closes the exposed margin of the capsule, and the external wound is closed in the usual manner." In similar cases Robert Jones often cuts down to but *not* into the capsule; seizes the capsule with two forceps, twists it tight and with sutures fixes the folded or twisted capsule so that it cannot relax.

Turner Thomas ("Journal A. M. A.," March 12, 1910) performs capsulorrhaphy through an incision in the axilla.

Step 1.—Make a cut in the axilla along the coraco-brachialis muscle from the side of the chest downwards for about 5 inches. Retract outwards the coraco-brachialis, biceps and pectoralis major. Retract inwards the axillary vessels and nerves as well as the musculo-cutaneous nerve. Doubly ligate and divide the anterior circumflex vessels and expose the latissimus dorsi in the floor of the wound. Locate and protect the circumflex nerve and the posterior circumflex vessels as they pass backwards. On a grooved director divide about half the width of the subscapular muscle, thus exposing the capsule.

Step 2.—Open the capsule by a cut about 1½ inches in length, in the line of the anterior glenoid margin and about ½ inch below it. Explore the joint for any obstruction to reduction.

Step 3.—Close the wound in the capsule by the overlapping method. Repair the wound in the subscapularis. Close the wound. Bind the arm to the side and support the wrist in a sling.

After-treatment.—On the ninth day the patient may put his arm through the sleeve of his coat. For three weeks keep the arm bound to the chest during the night. After which time forcible movements may be begun. Thomas finds that patients become able to raise their arms straight above their heads in from six to fifteen weeks after operation.

Clairmont-Ehrlich Operation.—Make an incision over the anterior portion of the deltoid and parallel to its fibres. Split the muscle.

Make an incision over the posterior portion of the deltoid and reflect upwards a flap of deltoid preserving intact the branches of the axillary nerve supplying it.

From the anterior incision pass a closed forceps through the split in the deltoid around the inner side of the humeral neck to emerge at the posterior deltoid wound. Grasp the mobilized flap of muscle, pull it through the tunnel, which has been sufficiently dilated to accommodate it, and suture it to the anterior deltoid wound. The whole operation is extra-capsular.

Clairmont and Ehrlich obtained good results in two cases.

In three cases of Lameris the immediate results were good but in two of them there was recurrence after eleven months. Seidel found that the longest muscle flap obtainable might be too short to reach to the anterior deltoid wound, so in one case he lengthened it by a graft of fascia with unfavorable result.

Kirschner's Operation.—*Step* 1.—Beginning ¾ inch below the middle of the spine of the scapula make a 2½–3 inch incision along the posterior margin of the deltoid. Expose the posterior margin of the deltoid and retract it upwards and outwards.

Step 2.—Recognize the circumflex nerve and vessels. Using these as a guide find the quadrilateral space bounded above by the teres minor; below by the teres major; internally by the long head of the triceps; and externally by the humerus. Retract the circumflex nerve and vessels downwards; bluntly penetrate the quadrilateral space.

Step 3.—Push the finger or a forceps forwards and upwards under the deltoid to the posterior edge of the acromion near its point. At this place make the forceps penetrate the deltoid and lift up the skin. Incise the skin over the point of the forceps.

Step 4.—Make an incision along the anterior margin of the deltoid and expose its border. With finger and forceps burrow under the muscle to the anterior margin of the acromion near its point and perforate the muscle. Push the perforating forceps through the skin incision made in Step 3.

Step 5.—Through the anterior incision pass the fingers or forceps around the neck of the humerus, hugging the bone, to emerge at the posterior incision.

Step 6.—From the thigh excise a strip of fascia lata about 8 inches long by 1¼ inch wide. Pull this through the tunnels which have been made around the shoulder. The course of the implant as it is pulled into place is (*a*) through the posterior incision, (*b*) through the quadrilateral space between the teres major and minor, (*c*) under the neck of the humerus to the anterior incision, (*d*) under the deltoid to the perforation in that muscle just in front of the acromion, (*e*) over the acromion (*f*) from without inwards, through the perforation in the deltoid and so under the deltoid to the posterior incision again, where it is fixed by a few sutures.

The result is a strip of fascia, outside the joint capsule, which slings the neck of the humerus to the acromion process.

Payr's Operation (Kleinschmidt, "Ergeb. d. Chir. u. Orthop." viii, 229).—Expose the joint capsule through Ollier's incision. Suture the base of a triangular flap of fascia lata by several rows of sutures to the insertion of the pectoralis major.

Under tension suture the apex of the flap to the coracoid process. Through a suitable incision behind expose the posterior margin of the deltoid and retract it upwards and outwards. Suture the apex of a triangular flap of fascia lata to the joint capsule above the head of the humerus. Suture the base of this flap, under tension, to the surface of the infra-spinatus and teres minor. Several rows of suture should be used.

Perthes ("Deutsche Zeitschrift für Chir.," lxxxv) believes habitual dislocation of the shoulders is generally due to fracture of the upper end of the humerus or of the scapula. Owing to muscular action or to direct violence the greater tuberosity is often fractured or the tendons give way near their insertion there, and are likely to unite to the capsule. In other cases the glenoid may be injured, giving rise to foreign bodies in the joint. Sometimes the trouble is due to relaxation of rupture of the capsule. The capsule is normally so large that it is capable of holding two humeral heads or of permitting subcoracoid dislocation (Perthes). It may be enlarged uniformly or the anterior part may be enlarged and form a sort of hernia.

In operating always open the joint to look for damage to the bones and ten-

dons. If the tuberosity is fractured or the tendons torn off from it, the injury must be repaired, or the joint will not be secure. The best method of joining the ruptured tendons to the bone is by double-pointed steel tacks (Perthes) which are either driven through the tendons into the bone or are first driven into the bone and the tendons then secured to them. The glenoid ligament may be fastened to the neck of the scapula in the same fashion. Perthes exposes the joint by turning backwards and upwards a flap of skin and of the whole deltoid muscle. This exposes the joint very well and the muscle is said not to suffer from the disinsertion, if sewed in place firmly. The joint may be reached from in front by an incision along the border of the deltoid, the anterior portion of which is severed near the clavicle. The tendon of the pectoralis major is cut and this muscle is drawn towards the breast. The end of the coracoid process is removed with a Gigli wire saw and the coraco-brachialis and short head of the biceps drawn down. The upper border of the subscapularis may be drawn back or severed. After suturing the tendons of the scapular muscles and repairing the glenoid ring, the capsule is drawn up with sutures so placed as to strengthen it. The muscles cut during the operation are then restored and the skin closed.

FIG. 1357.—Arthroplasty. (*Payr.*)

Arthroplasty of Shoulder.—The general principles governing the operation of arthroplasty are described on page 1052.

Step 1.—Expose the joint through Ollier's incision.

Step 2.—Overcome the anchylosis. In bony anchylosis resection and modelling of the head of the humerus will be necessary. See that motion is even more than normally free.

Step 3.—*Method A.*—Through an incision parallel to its fibres, expose the surface of the middle portion of the pectoralis major. Mobilize a flap from the pectoralis major, the pedicle of the flap being formed by its humeral insertion (Fig. 1357, Payr). Make a subcutaneous tunnel from the wound on the chest to that opening the joint and pull the pectoral flap through the tunne into this joint. Wrap the flap over the head of the humerus and fix it in position by a few sutures.

Method B.—Exactly the same as method A but the flap is formed of the fat and fascia covering the pectoralis major instead of muscular tissue.

Method C.—Carefully wrap the head of the bone in Baer's membrane (see p. 1055).

Step 4.—Close the wounds. Apply dressings.

CHAPTER XCIII

CLAVICULO-HUMERAL NEARTHROSIS

It is interesting and valuable to know that a useful new joint can be established after excision of the scapula and of the upper end of the humerus even when a useless flail-like articulation has been present for a long time. Ollier's case presents so many points of interest and his treatment of it is so suggestive in many ways that no apology is necessary for discussing it at some length.

The patient was wounded in the shoulder in 1871. He subsequently underwent many operations—sequestrotomies, typical resection of the humeral head, complete removal of the scapula, etc., etc. ("Revue de Chir.," July, 1899). Figure 1358 shows the appearance of the patient. The outer end of the clavicle was pulled upwards by the trapezius and was connected with the humerus merely by skin, fibrous tissue, and some atrophied bands of muscle. The arm itself drooped because of its own weight. The limb was useless though the muscles of the forearm and hand were well nourished. The upper end of the humerus was thin, pointed, surrounded by scar tissue, and about 2¾ inches distant from the clavicle. The muscles of the shoulder were so atrophied that only with difficulty could remnants of them be found among the scars of the incisions existing where the scapula had been. The deltoid had lost all its clavicular connections except its inner fibres which were stretched and atrophied. The rest of the deltoid had retracted to its lower insertion, curling itself up in a bunch over the upper end of the humerus. The pectoralis major formed the principal support of the arm.

Ollier operated as follows:

(1) Antero-lateral incision from the outer end of the clavicle downwards.

(2) Vivification of the under surface of the clavicle for an area of about 1½ square inches. This was done by turning aside a flap of periosteum.

(3) Extension of the incision sufficiently to permit the formation of a cavity through which the humerus could be brought into contact with the clavicle (care was here required to avoid injuring the vessels and nerves. It was necessary to excise some of the scar tissue before the humerus could be brought into proper position.

(4) Cutting off the pointed extremity of the humerus in order to obtain a surface large enough to unite to the clavicle. When removing the bone Ollier preserved its periosteum.

(5) Drilling of two holes through the clavicle and two holes (from before backwards) through the humerus. Wiring of the humerus to the clavicle.

(6) Suture of the periosteum of the humerus to that of the clavicle (*i.e.*, the reflected flaps of periosteum).

(7) Dissection and straightening out of the periarticular muscles so that they could be sutured where they would do most good, *e.g.*, the deltoid which was curled up on itself was freed from adhesions and then sutured to zius which was separated from the clavicular insertion:

FIG. 1358.—(*Ollier.*)

FIG. 1359.—(*Ollier.*)

deltoid as did not correspond to portions of the trapezius were sutur periosteum and tissues around the clavicle.

(8) Closure of the wound. The limb was immobilized for four but during that time the deltoid was stimulated by electricity applied a window cut in the dressings. After the above time no bony union h place. In time a useful and movable joint formed. Figure 1359 s patient twenty-five months after operation.

CHAPTER XCIV

OPERATION FOR SUBACROMIAL BURSITIS AND FOR RUPT THE SUPRA-SPINATUS TENDON

Codman's Bursitis is more common than any other lesion of the or inflammation of any other bursa. Normally, a bursa exists betv deltoid and acromion and the short rotators which form the capsul shoulder. When the arm hangs at rest a small portion of the bursa under the acromion process and the coraco-acromial ligament. When is abducted the base of the bursa which is on the tuberosity of the

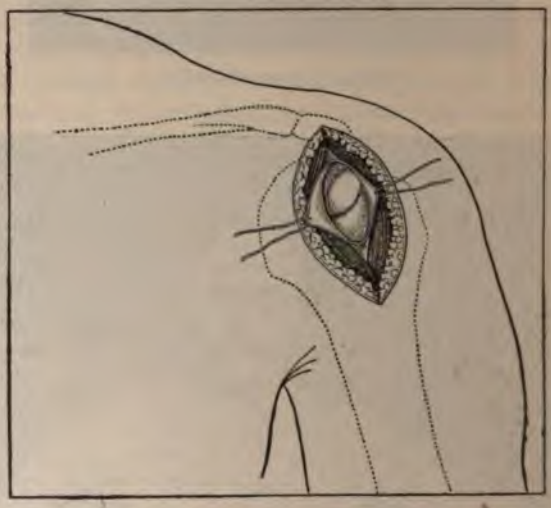


FIG. 1360.—Codman's bursitis. (*Codman.*)

passes upwards under the acremion and the coraco-acromial ligament. bursitis is present abduction and likewise external rotation become im In chronic inflammation the normally thin and pliable bursal walls thickened, and if simpler means of treatment fail, excision becomes ne

The Operation.—*Step* 1.—From a point midway between the and the acromion make a 2 to 2½-inch incision parallel to the fibre deltoid (Fig. 1360). Split the deltoid and enter the bursa as if it v peritoneum.

Step 2.—Excise the adherent or thickened portion of the bursa.

Step 3.—Attend to hemostasis. Close the wound in the deltoid with fine catgut sutures. Close the skin wound. Apply dressings. Begin motion in about ten days.

Brickner ("Am. J. Med. Sc.," March, 1915) notes that contusions or tears of the supra-spinatus tendon, even when the trauma is mild, are sometimes followed by single or multiple deposits of lime salts in the tendon or on its surface. When such are present and cause disability their removal is necessary. Brickner operates for Codman's bursitis as follows: Open the bursa through an incision which splits the deltoid from the outer border of the acromion downwards over the greater tuberosity, *i.e.*, towards the external condyle. With retractors open the bursa. Divide all adhesive bands. Excise any papilloma-like masses. Explore the whole bursa rotating and putting traction on the arm as may be necessary to facilitate palpation. Incise the floor of the bursa, in the same line as the skin incision, over the greater tuberosity and supra-spinatus

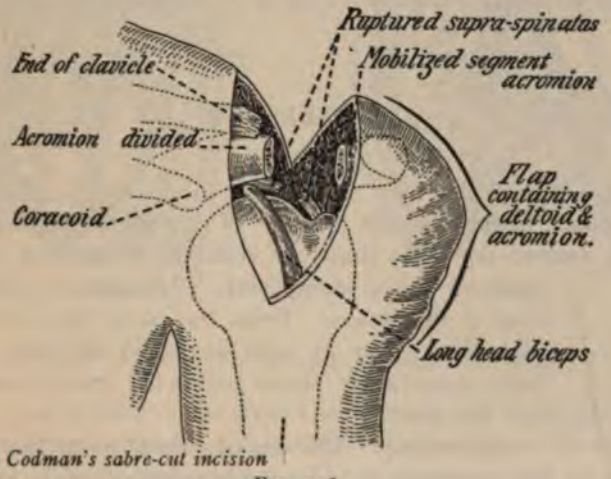


FIG. 1361.

insertion and dissect it up from the tendon. If any deposit, fluid or solid is found, remove such. If the tendon shows any superficial injury or tear within which is more of the solid or cheesy material clear such away and trim and suture the rent in the tendon. If the X-ray has shown calcareous material in the tendon, completely remove such through an axial split in the tendon and suture the wound with catgut. Close the wound in the floor of the bursa with fine catgut stitches. Smear the inside of the bursa with vaseline but leave no small lumps of the lubricant. Suture the roof of the bursa. Close the wound. Dress. Immobilize the arm in a position of abduction (120°) until healing has taken place.

Injury to the Supra-spinatus Tendon.—Codman has shown that the deltoid can act efficiently as an abductor only after the supra-spinatus has pulled the head of the humerus firmly against the scapular portions of the articulation; thus rupture of this tendon causes great disability and must be repaired. The operation is best carried out through *Codman's sabre-cut incision* which is very valuable for exploration of the joint and for the treatment of fracture—dis-

location or of irreducible dislocations. The operation is not suitable for tuberculosis or inflammatory lesions.

The Sabre-cut Operation.—Split the deltoid exactly as in exposing the subacromial bursa. Continue the incision directly back over the shoulder at the root acromion process. Divide the acromio-clavicular joint. With a Gigli saw divide the base of the acromion avoiding injuring the supra-scapular nerve as it passes through the great scapular notch. (Fig. 1361). Divide a few fibres of the trapezius and retract outwards the acromion along with the deltoid and the whole outer half of the wound just as if one opened the upper part of the seam of a coat sleeve and looked in at the top of the shoulder. If the supra-spinatus has been torn, the articular surface of the joint is visible; otherwise (if the operation is exploratory) that muscle must be divided before proper exposure is attained. It is easy to repair the tendon with sutures and to suture the acromio-clavicular joint by means of the surrounding firm fibrous tissue. The acromion may be united either by wiring or by suture of the surrounding soft parts.

CHAPTER XCV

ELBOW

Intra-articular Injection.—The technic of intra-articular injections has been so fully treated elsewhere that it is sufficient to mention the point of puncture of the elbow-joint. Recognize by palpation the head of the radius. From the outer side of the arm introduce a trocar at right angles to the long axis of the limb, immediately above the radial head, and penetrate into the joint.

FIG. 1362.—Excision of elbow.

Arthrotomy.—The remarks made on arthrotomy and on the treatment of wounds and infections of the knee (p. 1030) apply equally to the elbow. The incisions for arthrotomy should be ample. The best incisions are lateral. To gain free exposure of the joint, division of the external lateral ligament is necessary and does not interfere with function if well sutured. Willems principle of *active* motion begun immediately after operation (pp. 1030, 1031) is of great importance for drainage and function.

Resection or Excision of the Elbow. Posterior Vertical Median Incision.—*Step* 1.—Have an assistant hold the arm firmly in a position of partial flexion. Make a longitudinal incision from a point 2 inches above, to a point 2 inches below, the tip of the olecranon (Fig. 1362). The cut, following the middle line of the olecranon and lower part of the humerus, penetrates at once to the bone and opens the posterior part of this joint.

Step 2.—With a periosteal elevator or knife separate all the soft parts (including periosteum and inner portion of triceps tendon) from the olecranon process on the inner side of the vertical wound. In doing this, if one uses the

knife, one must strongly retract the tissues inwards with the nail of his left thumb and cut with *short* decided movements of the knife *on to the bone.* As such a manner of cutting is essential, but soon renders the knife as blunt as the proverbial ploughshare, it is well to have several knives prepared. *In all the cutting practised in resection of the elbow the edge of the knife must be directed against the bone* (Fig. 1363).

Continue the separation inwards until not only is the inner part of the olecranon bare of covering, but the same is true of the inner part of the lower end of the humerus and the internal epicondyle can be protruded into the wound.

FIG. 1363. FIG. 1364.

FIGS. 1363 AND 1364.—Excision of elbow. (*Schwartz.*)

The ulnar nerve lying in the groove between the olecranon and the internal condyle is raised up and retracted inwards with the rest of the soft structures (Fig. 1364). It should not be seen. The structures on the outer side of the elbow are to be treated in the same way as those on the inner side. The manœuvres described effect a complete decortication of the posterior and lateral surfaces of the bones forming the elbow.

Step 3.—Flex the elbow completely. Push the lower end of the humerus out of the wound and separate it from the soft structures in front to the desired extent. With a flat piece of metal (retractor or spatula) protect the soft parts in front of the elbow. Seize the lower end of the humerus with lion-jawed forceps and remove with a saw as much of it as seems desirable (Fig. 1365). Any operating saw is suitable. (Some surgeons use a Butcher's saw with its sawing edge turned towards the bow of the instrument. The sawing ribbon is placed in front of the bones while the bow is behind them, the bone is sawed through backwards, and all danger to the vessels anterior to the joint is averted.)

With the elbow still flexed, make the upper ends of the radius and ulna protrude through the wound and saw them off with the same precautions.

Step 4.—Review the wound to see if all osteal disease has been removed. Any diseased synovialis which may be seen must be cautiously and thoroughly removed by dissection.

How much bone ought to be removed? The line of section of the ulna should permit removal of the greater and lesser sigmoid cavities with the olecranon. The radius should be divided at the same level just below its head, above the biceps. Jacobson writes, regarding section of the humerus: "An insufficient amount is usually removed here, and limitation of subsequent movement thereby invited. It is generally considered sufficient to remove all the articular cartilage, the section being made to pass through the lower part of the coronoid and olecranon fossæ, and below the level of the epitrochlea on the inner, and through the epicondyle on the outer side. This is not enough.

FIG. 1365.—Excision of elbow.

The saw should pass at a higher level, *i.e.*, above the level of the epicondyle, and through the highest part of the epitrochlea, removing quite the lower two-thirds of this process. This is the very lowest level at which the surgeon should hold his hand if he desires to obtain good movement. And before he is satisfied on this point he should place the fingers of the affected limb, not only on the opposite shoulder and mouth (as is often done), but on the shoulder of the same side, and behind the back to the angle of the opposite scapula. Unless these movements are perfectly free, he should take another thin slice off the humerus, removing the whole epitrochlea. This step may seem to my younger readers a needless shortening of the limb, and likely to lead to a flail-joint. I can assure them that it is not so. As long as the elbow-joint is freely movable, shortening of the bones matters very little. If attention has been paid to the advice given and the soft parts separated very carefully and, as far as possible, subperiosteally from the epicondyle and epitrochlea, the joint will become sufficiently steady laterally as well as freely movable although these bony prominences have been freely removed. Another

which the surgeons should always apply before considering the section of the bones completed is the interval between the sawn ends. Prof. Annandale considers that 1½ inches should intervene between them when the bones are extended." This valuable advice of Jacobson does not apply when one covers the sawn surfaces of the bone with a flap of fascia and fat. If the operation has been undertaken for tuberculosis, rub iodoform into all raw surfaces. Suture. Provide drainage. Dress. As an alternative, fill the wound cavity with iodoform emulsion or its equivalent and close without drainage. It is generally recommended to place the partially flexed limb in a metal splint provided with an adjustable joint opposite the elbow. The young surgeon, especially in the country, will generally be without such apparatus, but in the author's experience a starch or light plaster bandage strengthened with strips of pasteboard or wire netting answers all purposes. Jones' metal splint Fig. 1366 is convenient and excellent. The after-treatment is the same as that described in the chapter on the operative treatment of old dislocations of the elbow.

FIG. 1366.—Splint immobilizing elbow-joint, allowing access to it. (*Robert Jones, British Med. Journ.*)

Kocher's Method.—Kocher is true to his principle that in arthrectomy it is far better to make a complicated skin incision than a simple one, if by so doing one can preserve intact not merely the muscles, but their nerve supply. Flex the arm to an angle of 150°. From a point 1½ to 2 inches above the articular line make an incision downwards along the outer edge of the humerus to the head of the radius (Fig. 1367). Continue the incision downwards along the outer margin of the anconeus to the ridge of the ulna about 2 inches below the tip of the olecranon. The incision is curved and should end a little to the inner (ulnar) side of the ulna. At the upper end of the incision, penetrate to the outer edge of the humerus by separating the supinator longus and the extensor carpi radialis longior in front from the triceps behind. From the external condyle downwards penetrate between the extensor muscles (extensor carpi ulnaris, etc.) in front and the anconeus behind, until the ulna is reached. In doing this the lower fibres of the anconeus must generally be divided. The rest of the operation requires no special description.

FIG. 1367.—Kocher's incision.

Ollier's Bayonet Incision.—From a point 2¼ inches above the joint-line make a vertical incision along the outer margin of the humerus between the triceps and supinator longus to the tip of the external condyle. From the tip of the condyle continue the incision downwards and inwards to the base of the olecranon, then change the direction of the incision once more so as to make it follow the posterior border of the ulna downwards for 1½ to 2 inches (Fig. 1368). Make a second incision, 1 inch long, over the internal condyle.

Posterior Flap Operation.—Morison operates as follows: From a point over the internal condyle make an incision upwards for about 2 inches, corresponding to the inner intermuscular septum. Make a similar incision on the outer side of the limb (Fig. 1369). Join the upper ends of the two vertical cuts by a curved transverse incision, the upper convexity of which is 3 inches above the olecranon. Expose the ulnar nerve through the inner incision and protect it. Turn down the skin flap outlined for a distance of 1 inch. Divide the triceps transversely. Turn the skin flap and triceps tendon downwards. The rest of the active operation requires no special description. Close the wound by suturing the divided triceps and then the superficial wound. Morison permits no motion for two weeks, after which time he keeps the limb extended at night and fully flexed during the day.

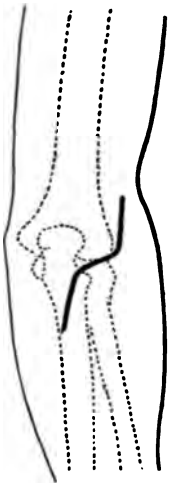


FIG. 1368.—Ollier's incision.

FIG. 1369.—Rutherford-Morison's incision.

Bardenheuer's Operation (Lossen, "Deutsche Zeitschrift für Chir.," xcii, 120). **Extra-capsular Arthrectomy.**

Step 1.—Reflect a horseshoe-shaped flap of skin, having its pedicle above, from the posterior aspect of the joint.

Step 2.—Divide the triceps tendon above the olecranon.

Step 3.—By dissection lay bare, but do not penetrate, the posterior and lateral surfaces of the articular capsule.

Step 4.—Divide the humerus and retract its articular end downwards (Fig. 1370), thus exposing the anterior surface of the joint.

Step 5.—Separate the overlying soft structures from the anterior surface of the capsule.

Step 6.—Divide the ulna. At a lower level divide the radius. (The section of the radius at a lower level than that of the ulna is important for the preservation of pronation and supination.) The articular ends of the bones plus the whole joint cavity can now be removed in one piece.

Step 7.—With chisel, forceps, or saw cut a V-shaped notch in the humerus

(Fig. 1370). Trim the upper end of the ulna so as to fit into the notch in the humerus while the forearm is held in a position of a little less than a right angle to the upper arm. Unite the ulna to the humerus by means of a nail (Fig. 1371).

Step 8.—Close the wound.

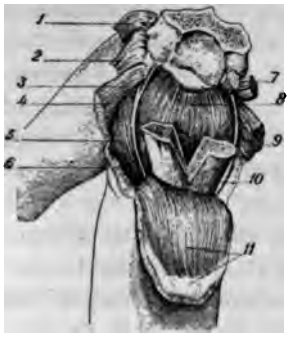


FIG. 1370.

FIG. 1371.

FIGS. 1370 AND 1371.—Bardenheuer's operation. (*Lossen.*)

FIG. 1370.—1. Anconeus. 2. Ext. digitorum. 3. Division musculo-spiral nerve. 4. Ext. carpi radialis longior. 5. Supinator longus. 6. Musculo-spiral nerve. 7. Pronator radii teres. 8. Brachialis anticus. 9. Flexor muscles divided. 10. Ulnar nerve. 11. Tendon of triceps.

FIG. 1371.—1. Anconeous. 2. Extensor com. digitorum. 3. Division musculo-spiral nerve. 4. Ext. carpi radialis longior. 5. Supinator longus. 6. Musculo-spiral nerve.

Atypical Resection of the Elbow.—Access to the joint is obtained through the posterior longitudinal incision already described. The base of the olecranon process is cleared of its coverings and divided transversely either from without inwards with a chisel, or from within outwards with a Gigli wire saw. The olecranon is reflected upwards with the attached triceps tendon. Examine the olecranon carefully as it is the most common site of osseous foci of disease in tuberculosis of the elbow. With a chisel or sharp spoon remove diseased bone wherever found. With forceps and knife or scissors excise diseased soft structures. Thoroughly cleanse the joint cavity. Reunite the olecranon to the ulna with bone pegs, steel nails (the ends protruding through the wound), silver wire, or chromicized catgut. Close the wound, provide for drainage, and dress. Many surgeons advise that the limb be kept in an extended position for two weeks. The after-treatment is practically the same as that for other elbow-joint resections.

Fritz König ("Zent. f. Chir.," xiii, June, 1914) uses various methods by which to gain access to the elbow-joint for the treatment of strictly localized disease (synovial tags; floating cartilages; osteochondrolysis; fractures) and has had no trouble from subsequent ankylosis. (1) If the widest possible exposure is required use the posterior transverse incision with division of the olecranon (Trendelenburg). Avoid injuring the ulnar nerve. This method gives the least good functional results.

(2) Anterior median incision along the median nerve. To avoid injuring the nerve branch going to the pronator teres König opened between the pronator and the flexor dig. sublimis and removed a large loose cartilage from in front of the trochlea.

(3) Internal lateral incision separating the flexor muscles from the condyle and retracting them forwards. This gives good access to the inner portion of the joint.

(4) Anterior lateral incision between the supinator radii longus and the brachialis anticus. Retract the musculo-spiral (radial) nerve outwards. Separate the upper capsular attachment. This gives the most clearly defined anatomic access to the joint; through it Kōnig removed a traumatic loose cartilage from beside the trochlea and the capitulum humeri.

(5) External lateral incision (humero-radial incision). Separate the upper capsular attachment to the external condyle. This gives excellent access to the most common site of osteochondrolysis and synovial tags. Through this incision it is also easy to resect the head of the radius or even to excise the elbow-joint.

Arthrodesis.—Occasionally after very extensive removal of bone in excision of the elbow a flail-joint results. If exercises, etc., or the use of some supporting apparatus do not lead to tolerable results, it becomes necessary to operate. The operation is practically that for ununited fracture and requires no special description. The endeavor must be to obtain bony union with the elbow flexed to such an angle that the fingers may be brought up to or nearly up to the mouth. In cases of paralysis when the most careful treatment has failed, and when no hope exists of obtaining a useful joint by means of tendon transplantation or of nerve anastomosis, it becomes necessary to operate for the relief of the resultant and useless flail-joint. The joint must be exposed as in excision; a thin shell of bone must be removed from the humerus and the forearm bones; the sawn surfaces must be brought into good apposition and kept there until bony union has taken place. Of course care must be taken to insure a useful position of the elbow.

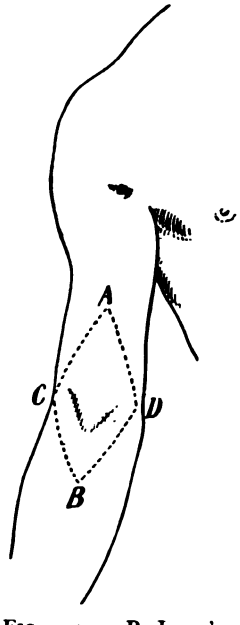


FIG. 1372.—R. Jones' arthrodesis.

Robert Jones does *not* consider the hip, wrist, and elbow-joints fitted for bony fixation. In that uncommon type of paralysis in which the muscles of the hand are acting, but the shoulder and elbow are flail, it is necessary to fix the arm in acute flexion so that the functioning hand may be of use. Jones does this "by the excision of the skin flaps, fixing the forearm to the arm, which is infinitely preferable to an arthrodesis of the elbow."

Jones' Operation.—*Step* 1.—At the junction of the middle and lower thirds of the anterior surface of the upper arm choose the point A (Fig. 1372). At the junction of the middle and upper thirds of the forearm choose the point B. Between A and B remove a diamond-shaped area of skin A B C D.

Step 2.—Attend to hemostasis. With sutures unite the raw surface A C D to the raw surface B C D in such a fashion that A is united to B and the cut edge A C to C B, etc. Apply dressings. Use a sling for some months, i.e., until contraction is well advanced.

CHAPTER XCVI

OLD DISLOCATION OF THE ELBOW

The common causes which impede reposition of a dislocated elbow-joint are: (1) Fragments of bone separated from the articular ends. (2) Contraction and malposition of torn portions of capsule and ligament. (3) Organization of blood-clot. (4) The filling up and obliteration of the olecranon and coronoid fossæ. When sufficiently good results cannot be obtained by means of non-operative treatment, operation is generally justifiable. The operation of choice is "Operative Reposition;" if this proves impossible or inadvisable, it is easy to proceed to excise and interpose a flap of fat and fascia between the divided bones.

Operative Reposition.—Bunge ("Archiv für klin Chir.," lx, 557) gives an excellent account of the operation as practised in von Eiselberg's clinic. The following is based largely on Bunge's article:

Apply an elastic constrictor. On the outer side of the elbow-joint make an incision about 4 inches in length (Fig. 1373). This cut in part of its course lies between the extensor carpi radialis longior and the extensor communis digitorum. Expose the dislocated head of the radius and lateral part of the humerus. Divide all tense bands of scar tissue and, subperiosteally, lay bare the whole upper end of the radius and the outer side of the humerus *at least* as far as the origin of the joint capsule. This is done with scissors and periosteal elevator. Through the above incision inspect the condition of the olecranon and coronoid fossæ and the articular end of the ulna. Remove all abnormal masses of tissue until the fossæ are clear and the normal configuration is displayed. Carefully hunt for and remove any displaced fragments of bone. The articular ends of the bone can now, occasionally, be luxated through the wound; the median side of the joint cleared of scar tissue and the soft parts separated from the humerus and ulna in the same manner as already described.

FIG. 1373.—Dislocation of elbow.

Replace the bones. Test the mobility of the joint. If movement seems to be at all impeded, make a longitudinal incision about 4 inches in length along the inner side of the joint. Remember the location of the ulnar nerve and avoid injuring it. The cut is made a little in front of the internal epicondyle. Through this wound subperiosteally separate the soft parts from the bones until free motion is obtained. Remove the tourniquet and attend to hemostasis with the most minute care. This is of extreme importance, as the occurrence of a hematoma interferes with the after-treatment. The articular capsule, the covering soft parts, and the skin are each *separately* sutured with catgut. Dress and put

up in a starch bandage strengthened by strips of pasteboard or wire nettin The joint is to be fixed at an obtuse angle and fully pronated.

After-treatment.—The sooner the after-treatment is begun, the better t result will be. As early as the third or fifth day begin making daily passi movements. As soon as the wound has healed the movements must be suppl mented by massage and warm baths to the arm. At an early date some for of pendulum apparatus may be used (sand-bag fixed to the wrist) as a means exerting continuous passive motion. Active movements should be begun earl If any signs of inflammation appear, restrict or stop all exercises until danger h passed. If a hematoma forms, it must be emptied at once.

Schlange considers that the hindrance to reduction is usually a fracture of t articular end of the humerus which has not been properly corrected or in whi there is an excess of callus. He operates as follows:

1. Make an incision, on each side, from the points of the epicondyles down wards, inwards and backwards to the ulna about 1 inch below the base of th

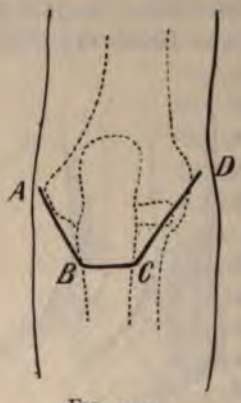


FIG. 1374.

FIG. 1375.

FIGS. 1374 AND 1375.—Schlange's operation.

olecranon. Unite these converging incisions by a transverse cut across the bac of the ulna (Fig. 1374). Remember the location of and protect the ulnar nerv The more or less horseshoe-shaped incision described penetrates to the bon

2. With a saw introduced through the transverse portion of the incisio divide the ulna obliquely upwards and forwards so as to separate the olecrano process and a wedge-shaped portion of the shaft from the ulna (Fig. 1375

3. Reflect upwards the flap of skin, triceps tendon, and bone, and thus free expose the whole interior of the joint.

4. Remove any excessive callus and correct any defect which interferes wit reduction. Reduce the dislocation.

5. Replace the osteoplastic flap. Unite the sawn surfaces of the ulna b means of a nail which penetrates the skin and thus can be subsequently remove Suture the periosteum. Close the wound. Dress. Immobilize with the elbo extended. Remove the nail from the bone in about ten days. Begin passiv motion early (Schlange, "Archiv. für. klin. Chir.," lxxxi, Part II).

The head of the radius may be dislocated forwards, the ulna remaining *i situ*, and the remains of the orbicular ligament may be so placed between th

bones that reduction becomes impossible; under these circumstances operation may be necessary. Open the joint by Kocher's external incision (see p. 1111). Pick up the torn ends of the orbicular ligament. Reduce the dislocation. Repair the ligaments by means of sutures. Close the wound. Apply dressings.

C. C. Elliott (China Med. J., July, 1916 and personal communication) finds many cases of old dislocation in China. In posterior dislocation of the elbow he operates as follows: Split the insertion of the triceps tendon and separate the two halves from the olecranon along with the periosteum. Divide the base of the olecranon and remove that process. Pass a lever (the curved handle of a dental forceps is good) into the joint and lever the bones into position after flexing the forearm to or beyond a right angle.

CHAPTER XCVII

ANCHYLOSIS ELBOW

Anchylosis of Elbow.—The treatment of fibrous anchylosis consists in breaking down the adhesions, under an anesthetic, and in keeping them from reforming by means of proper passive and active exercises. Occasionally in very stubborn cases it may be necessary to operate in the same manner as for osseous anchylosis. When osseous anchylosis is present treatment may or may not be necessary. If the elbow is fixed at such an angle that the patient gets fair use of the limb and if elbow immobility does not, for the individual affected, entail much disability, then no treatment is demanded. If however, owing to faulty position plus immobility, there is distinct disability, operation is indicated. Until recently the operative treatment was principally directed against the faulty position rather than against the immobility.

This treatment consisted in ordinary excision which was made very extensive if the endeavor was to obtain motion. Thanks to hints thrown out by Verneuil (in 1863), Ollier, Helferich, Rochet, etc., Nélaton (in 1902) proposed a general method of treatment of bony anchylosis by interposition of flaps of muscle. J. B. Murphy (in 1904) showed that fat and fibrous tissue was more suitable than muscle for this purpose as it is from such tissue that the synovialis is originally formed. For bony anchylosis of the elbow it is no longer essential to make a very extensive resection; it is only necessary to remove enough bone to permit of free motion *after* the sawn surfaces have been recovered with a proper flap of muscle or fascia *and* after the wounds in the soft parts have been closed.

Method A.—The author devised and successfully used the following method: Render the limb bloodless. Apply an elastic constrictor.

1. To the outer side of the middle line make a vertical incision from a point 2 inches above to one 3 inches below the tip of the olecranon.

2. Reflect outwards, by dissecting against the bone, all the soft parts external to the incision, laying bare the outer edge of the lower end of the humerus and the outer side of the olecranon, but leaving the annular ligament, if possible, intact. Do the same on the inner side of the wound. Remember the ulnar nerve.

With an osteotome separate the olecranon from the humerus. Remove

most of the olecranon. Divide the bony tissue uniting the humerus to the ulna and radius. Completely divide the lateral ligaments. Flex the elbow acutely. With the Gigli wire saw remove a small portion of the lower end of the humerus. Remove the articular surface of the ulna and model a new sigmoid cavity. If necessary, remove part of the head of the radius. Divide any bony tissue uniting the radius to the ulna, if possible preserving part or all of the annular ligament. Smooth and properly shape the opposing surfaces of the radius and ulna. It is usually easy to find enough soft structures (fat, fascia, muscle) to interpose between the radius and ulna where they normally articulate without formally fashioning a flap for the purpose. Trim the edges of the sawn surface of the humerus.

4. Remove the elastic constrictor. Attend to hemostasis. Pack the deep wound with hot gauze. Replace the soft parts in position over the gauze.

5. On the outer side of the original wound reflect the skin from the fat and deep fascia for a great distance (Fig. 1376). Outline and dissect up a flap having its pedicle above the joint-line. The flap consists of fat, fascia, and some of the superficial fibres of the subjacent muscles (Fig. 1376) (anconeus, ext. carpi ulnaris, etc.), and must be large enough to completely cover the lower end of the humerus and 1 inch of its anterior and posterior surface.

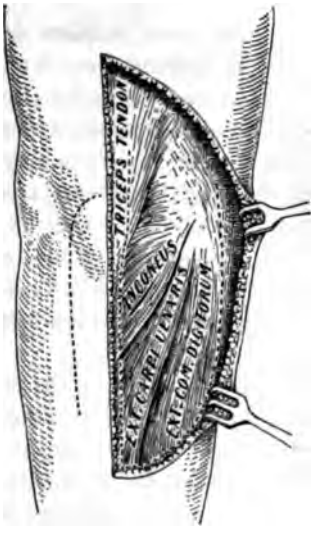


FIG. 1376.—Arthroplasty, author's method.

6. Remove the pack from the deep wound. Wrap the flap over the lower end of the humerus, fixing it with a few stitches of fine catgut.

7. Flex the arm to about a right angle. Replace the tissues as well as possible into their normal positions. Most of the triceps tendon is intact (on the inner side of the original wound) and continuous with the periosteum of the ulna. Close the deep wound with catgut sutures. Provide drainage (rubber tissue). Close the skin wound. Dress. Apply a right-angled anterior splint. After-treatment: Remove the drain in about twenty-four hours. Begin motion in about eight days.

Method B.—Expose the joint as in Method A.

2. Rupture of the Anchylosis.*—First try to rupture the anchylosis by manual force. If this fails, introduce a rugine between the olecranon and the humerus as a lever or, better, divide the olecranon near its base, and after having cut the fibrous bands uniting the humerus to the forearm bones, once more try to break the anchylosis by manual force.

If, as is rare, the above means fail, one must separate the bones with chisel and mallet.

3. Divide the humerus at a point where its diameter begins to diminish (Fig. 1377). Fashion the sawn surface so that it is convex from before backwards.

*The description of this and the following method is based on Huguier's Traitement des Ankyloses.

4. Resect the olecranon at its base. Fashion the bone as shown in Figs. 1378 and 1379. Resect that portion of the head of the radius which projects above the sawn surface of the ulna. If anchylosis exists between the radius and ulna separate these bones with a fine chisel.

5. Remove the elastic constrictor. Attend to hemostasis with usual care.

6. **Interposition of Muscle.**—(*a*) Flex the forearm acutely. Divide the anterior articular capsule transversely at its ulnar insertion; continue this incision into the brachialis anticus, so as to form the muscular flap (Fig. 1379) (Quénu). With the flap cover the sawn surface of the humerus. The rest of the operation is as in Method A.

(*b*) Berger obtains the muscular flap from the anconeus. Figure 1380 sufficiently explains the operation.

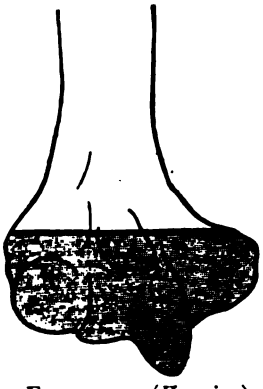


FIG. 1377.—(*Huguier.*)

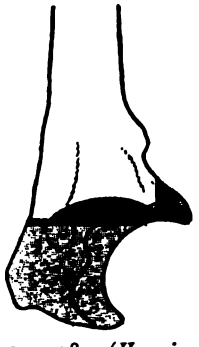


FIG. 1378.—(*Huguier.*)

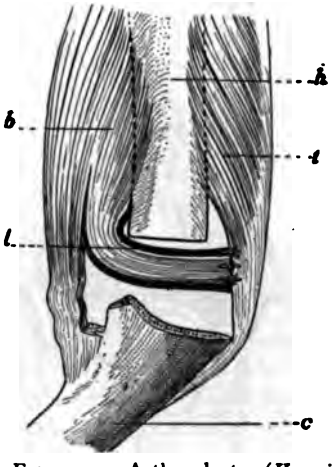


FIG. 1379.—Arthroplasty. (*Huguier.*)
b, Brachialis anticus; *h*, humerus; *c*, ulna; *t*, triceps; *l*, anterior ligament turned in with flap.

Method C.—Lateral Incisions (Ombrédanne).—Make a 5-inch vertical incision on the inner side of the elbow. Isolate and protect the ulnar nerve. Denude the epitrochlea. Divide the lateral ligament. Denude the anterior surface of the humerus. On the outer side of the elbow make a vertical incision downwards from a point 2½ inches above the joint-line. If it is necessary to carry this cut more than 1½ inches below the joint-line it ought to incline backwards so as to avoid injury to the radial nerve. Denude the epicondyle with a knife, the anterior surface of the condyle with a rugine. Divide the external lateral ligament. Rupture the anchylosis as already described. Make the lower end of the humerus protrude through the internal wound and divide it transversely immediately below its lateral tuberosities. Figure 1381, in conjunction with what has already been written, sufficiently describes the remainder of the operation.

Transplantation of Cartilage in the Treatment of Anchylosis.—Weglowski's operation ("Zentralblatt für Chir.," 1907, No. 17). This operation has been performed successfully by Weglowski and by Diakonow in bony anchylosis of the elbow.

Step 1.—Expose the elbow. Remove all excess of bone. Model the e the bone so as to form proper articular surfaces.

Step 2.—Expose the cartilage of the sixth and seventh ribs and from remove two plates of cartilage with perichondrium the full length and wi the costal cartilage and about one-half its thickness.

Step 3.— Place these strips of cartilage between the new-formed ar surfaces of the elbow. The strip laid against the articular surface of t merous must have its perichondrial surface directed towards that bone. unnecessary to fix the cartilage in position with sutures.

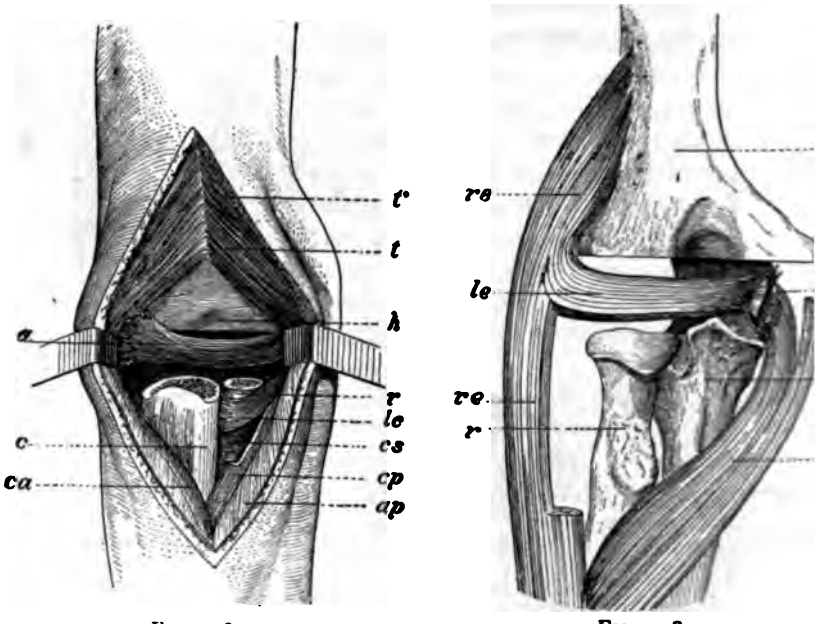


FIG. 1380. FIG. 1381.

FIGS. 1380 AND 1381.—Arthroplasty. (*Hugnier.*)

FIG. 1380.—*a*, Anconeus interposed; *r*, radius; *c*, ulna; *lc*, flap of ext. ulnaris; *cp*, interposed; *t*, *t'* tendon triceps; *ca*, flexor ulnaris; *cs*, supinator brevis; *ap*, aponeurosis.

FIG. 1381.—*h*, Humerus; *c*, ulna; *le*, external muscle flap; *li*, internal muscle flap; *r*, radius, *re*, e carpi radialis longior.

Step 4.—Close the wound. Immobilize. After ten days begin activ passive motion. In both cases the result was good. One patient died of pl pneumonia five weeks after operation, thus giving opportunity for anato examination which showed that the transplanted cartilage lived and was a ing itself satisfactorily to its new surroundings and functions.

Bony Anchylosis Elbow.—Buchmann's Operation.—Transplantation Entire Joint.—P. Buchmann has operated as follows in two cases of bony a losis of the elbow ("Zentralblatt für Chir.," 1908, No. 19).

Step 1.—Make a posterior longitudinal incision down to the triceps te and the olecranon. At the outer side of the olecranon divide all soft longitudinally. With an elevator separate and push inwards the triceps te remnants of capsule, and the periosteum.

Step 2.—Divide the olecranon at the level of the joint. Divide the lateral mnants of capsule. Divide the bony union between the humerus, ulna and dius.

Step 3.—Flex the elbow. From the trochlea cut out a niche, wider in front an behind and narrower above than below. Remove a very thin slice from e lower end of the humerus.

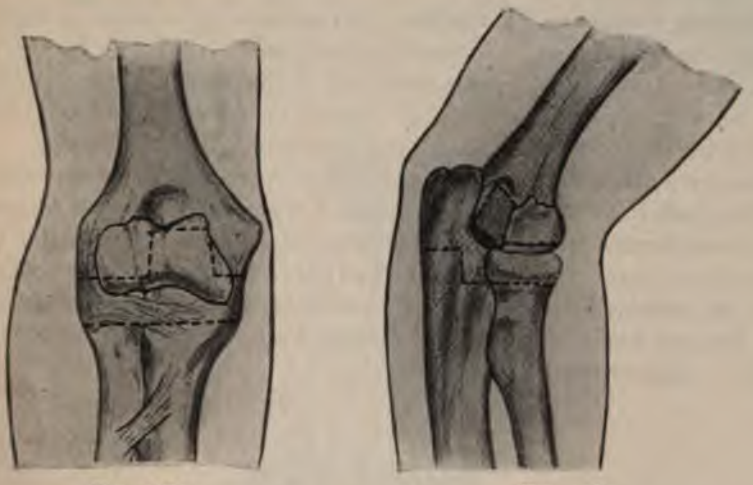


FIG. 1382. FIG. 1383.

FIGS. 1382 AND 1383.—Buchmann's transplantation of joint. (*Buchmann.*)

Step 4.—Separate the brachialis anticus from its insertion into the coronoid rocess. Cut a quadrangular niche in the ulnar epiphysis (Figs. 1382, 1383). emove the head of the radius and separate the radius from the ulna.

FIG. 1384.—Result of transplantation joint. (*Buchmann.*)

Step 5.—Excise the first metatarso-phalangeal articulation without opening e joint itself. Remove with the joint sufficient metatarsus and phalanx to t into the niches cut in the humerus and ulna.

Step 6.—Implant the excised joint into the wound at the elbow in such a manner that its plantar surface faces backwards. Fit the end of the metatarsus and the phalanx into the corresponding niches cut in the humerus and ulna.

Step 7.—Close the elbow wound and immobilize in the extended position. Close the wound in the foot.

Figure 1384 shows a skiagram of one of Buchmann's cases ten and one-half weeks after the operation.

Myositis Ossificans Traumatica.—Occasionally as a result of injury, bone develops inside a muscle. Examples of such lesions are "drill bone," "rider's bone," etc. Probably the commonest site of the trouble is the brachialis anticus muscle. Operative treatment consists in exposing the bone through a suitable incision and excising it. No precise description is necessary.

Auvray writes ("La Presse Med.," July 3, 1912) concerning osteomata situated in muscle but unattached to the bone: "it is certain that their extirpation is only exceptionally followed by recurrence (in 92 cases collected by Chabrol there were 75 cures, 15 improvements and only 2 failures). On the other hand, when the osteomata are consecutive to articular traumata, recurrence is much more frequent and the results of treatment much less satisfactory (in 23 cases, 7 cures, 7 improvements, 9 failures)."

CHAPTER XCVIII

WRIST

Anatomically, the wrist-joint is formed between the radius and the triangular fibro-cartilage above and the first row of carpal bones below. Below the anatomical wrist-joint there are the carpal and the carpo-metacarpal joints. These joints are surrounded by many ligaments. Surgically, the series of joints and bones between the radius and the metacarpal bones may be considered as one structure, completely surrounded by one periosteo-ligamentous investment, an investment which is here thicker, there thinner; here more firmly, there less firmly united to its contents. Numerous tendons pass over or are inserted into this ligamentous investment, so that if the latter is separated from its contained bones the tendons also are separated or raised from them without being injured.

Wounds and infections of the wrist should be treated on the principles laid down on p. 1030.

Typical Subperiosteal Resection of the Wrist.—Ollier's Operation.

Step 1.—**Incision through the Skin and Ligamentous Investment.**—Note the position of the styloid processes of radius and ulna and imagine a line joining these two points (interstyloid line). Note the tendon of the *extensor indicis*, or if this cannot be made out, the base of the second metacarpal bone.

Beginning at the middle of the dorsal aspect of the second metacarpal bone, make an incision upwards and inwards a little to the radial side and following the line of the tendon of the extensor indicis (Fig. 1385). This oblique incision reaches the middle point of the interstyloid line where its direction is changed to that of the axis of the forearm.

Recognize and retract inwards the tendon of the extensor indicis, without opening its sheath. This exposes the insertion of the extensor carpi radialis brevior. Incise the periosteum of the head of the third metacarpal to the inner side of the insertion of the extensor carpi radialis brevior. Continue the periosteal incision upwards, dividing the joint capsule and the posterior annular ligament between the extensor indicis and the long extensor of the thumb.

On the ulnar side of the wrist make an incision from a point 1¼ inches above the point of the ulnar styloid process to a point ¾ inch above the base of the fifth metacarpal bone. The incision is to the inner side of the extensor carpi ulnaris, and is carried directly to the bone.

FIG. 1385.—Ollier's operation. (*After Farabeuf.*)

R', Radius; *C*, ulna; *Sc.*, scaphoid; *t*, trapezoid; 1-1', tendon ext. carpi radialis long.; 2-2', ext. carpi radialis brevior; 3-3', ext. ossis metacarpi pollicis; 4-4', ext. brevis pollicis; 5-5', ext. longus pollicis; 6-8-9-10, ext. communis; 7-7', ext. indicis; 11-11', ext. minim. dig.; 12-12', ext. carpi ulnaris.

Step 2.—**Removal of the Carpal Bones.**—Through either the dorsal or ulnar incision separate the ligamentous investment from the underlying structures, seize the individual bones in forceps and dissect them out. If the ligamentous investment is properly separated, the tendinous insertions will be preserved and the least possible amount of damage inflicted. The pisiform bone may or may not be removed. The unciform process may be divided while its bone is being removed and if not diseased it may be left *in situ*.

Step 3.—After the removal of the carpal bones it is easy to resect the lower end of the radius and ulna and to remove the triangular cartilage. The carpal ends of the metacarpal bones are readily excised with rongeur forceps.

Step 4.—Review the whole wound and excise with forceps and scissors any diseased tissue. Unite by suture the divided annular ligament. In cases of tuberculosis rub the wound cavity with iodoform. Provide drainage. Close the wounds with sutures. Some surgeons pack the wound with iodoform gauze and suture after the lapse of a few days, or they apply, but do not tie, the sutures on the completion of the operation, pack with gauze, remove the pack after a few days, and tie the sutures already in place. Instead of the above dressings the wound may be filled with iodoform or bismuth paste and closed with or without drainage. After the dressings have been applied the member must be fixed with the hand in a position of dorsal flexion. For this purpose Robert Jones' 'cock up' splint is good. Whatever means of immobilization is adopted, the fingers and thumb must be left uncovered so that they may be exercised as early as possible.

After-treatment.—At the earliest date possible practise passive. Active movements of the fingers and thumb must be early attempted and the patient told to make "piano-playing" movements. All these movements are of extreme importance so that fibrous union of the tendons may be avoided. The limb must be kept immobilized until the wrist has solidified considerably. This may take six months or even longer. When the wound is healed a light splint, *e.g.*, Ollier's wire splint or some leather device, should replace the original splints. The extensor and flexor muscles of the wrist should be kept in "condition" by applications of electricity. The splint should be removed several times daily and movements of the wrist practised. Much patience is required before a good result can be obtained.

The operation is usually performed for tuberculous disease. Müller has excised the wrist in arthritis deformans with good results. In one case of arthritis deformans the author obtained a result which was only fair, but this he thinks partially due to want of completeness in the operation done.

FIG. 1386.—Taylor's operation. (*Taylor.*)

Wm. J. Taylor's Operation ("Annals of Surgery," xxxii, 360).—This is a modification of an operation suggested by Studsgaat and carried out by Mynter.

Apply an elastic constrictor above the elbow.

Step 1.—Make a longitudinal dorsal incision from the lower end of the radius downwards along the line corresponding to the space between the second and third metacarpal bones (Fig. 1386). Through this incision penetrate between the metacarpal bones to their palmar surface, but be careful *not* to injure the soft tissues of the palm. (Mynter made a small palmar as well as a long dorsal incision.) Split the carpal bones. This splitting is easy, as, when operation is

required because of tuberculosis, the bones affected are softened or destroyed by the disease.

Step 2.—Remove all diseased tissue. Clean thoroughly. Lessen the size of the deep wound by means of a few sutures. Loosely pack with gauze. Partially close the skin wound. Dress. Apply a suitable splint.

Bardenheuer's Operation.—Through a suitable incision remove the carpus *en masse.* If possible, preserve the trapezius so as to retain the mobility of the thumb. Obliterate the dead space left by the removal of the carpus in the following manner: Divide the three middle metacarpal bones so as to form a wedge whose apex is formed by the third metacarpal. Fashion the forearm bones so as to form a V-shaped surface and into this V place the metacarpal wedge. Nail the third metacarpal to the radius, the fifth metacarpal to the ulna, and the trapezius to the outside of the radius. Any tendons which have been resected because of involvement in the disease are now reunited by suture.

Atypical Resection of the Wrist.—In tuberculosis, limited foci of disease may be safely reached through small incisions on any part of the dorsum of the wrist if care is taken to avoid division of tendons. In more advanced carpal disease access may be obtained through Ollier's incisions and the affected structures removed with the sharp spoon, forceps, and scissors. After such operations the wounds are carefully cleaned, iodoformized and either packed with iodoform gauze or closed by suture after drainage is provided.

CHAPTER XCIX

WRIST ANCHYLOSIS

Method A.—Nélatons' Operation. ("Rev. d'orthopedie," 1905, Nélaton; "Traitement des Ankyloses," Huguier).

1. Expose the wrist-joint by a longitudinal incision along the radial side of the extensor tendons of the index finger. Extend the incision upwards so as to freely expose the lower portion of the extensor communis digitorum. Retract the extensors of the thumb outwards, those of the fingers inwards.

2. Break down the anchylosis by manipulation or with the chisel. Excise the first row of carpal bones, except the pisiform. Resect sufficient of the second row of bones in a curve, to give them the shape of a condyle.

3. From the outer side of the fleshy body of the extensor communis digitorum cut a flap having its pedicle below. The flap must be about ½ inch wide by 2 inches long. Place the flap transversely in the gutter formed by the removal of the carpus and fix its end to the fibrous tissue at the inner side of the joint (Fig. 1387).

4. Stop all bleeding. Close the wound after providing for drainage. After two weeks begin motion. Nélaton operated successfully in this fashion in a case of anchylosis from arthritis.

Method B.—The author suggests the following method as simpler and at least as efficacious as Nélaton's; it is identical with an operation for anchylosis of the first carpo-metacarpal which he performed successfully.

1. Expose the wrist-joint by a longitudinal incision along the radial side of the extensor of the index finger. Divide the skin, fascia, etc., so as to open the joint. Do not cut the fascia upwards any farther than is absolutely necessary. Break down the anchylosis and excise bone from the carpus to the extent necessary for free motion, as in Nélaton's operation.

2. Extend the original incision upwards *dividing the skin alone* (Fig. 1388). Expose a large surface of the fascia of the forearm. From the fascia dissect

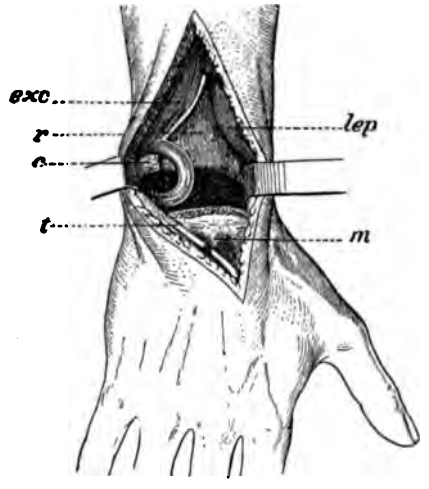


FIG. 1387.—Arthroplasty. (*Huguier.*)
r, Radius; *c*, ulna; *m*, metacarpus; *exc.*, ext. communis digitorum; *t*, tendon ext. indicis; *lep*, ext. long pollicis.

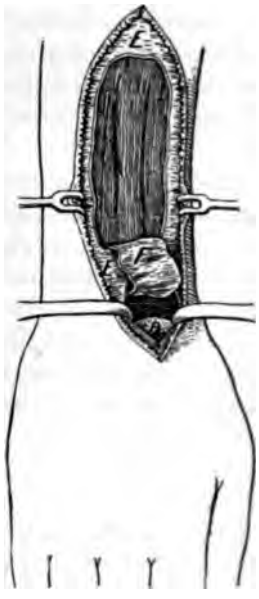


FIG. 1388.—Arthroplasty.
E, Deep fascia; *F*, flap of fascia; *D*, carpal bones.

downwards a flap of fascia, fat, and a few muscle fibres (pedicle below and sufficiently above or to the side of the opening made in the fascia for the arthrectomy to permit of good nutrition).

3. Turn the flap of fascia downwards, tuck it into the deep wound so that it completely envelops the articular surface of the radius. Fix the flap in position with fine catgut sutures.

4. Close the wound after providing for drainage. Apply dressings and a splint. Remove the drain in twenty-four to forty-eight hours. Begin motion as soon as the wound is healed.

CHAPTER C

METACARPO-PHALANGEAL DISLOCATIONS

Dorsal dislocations of the first metacarpo-phalangeal joint are occasionally irreducible by manipulation and demand operation. Stimson (Fractures and Dislocations, p. 707) writes: "The cause of this difficulty, in all the cases in which I have exposed the joint, has been the torn edge of the anterior ligament closely drawn across the back of the metacarpal behind its head, and a slight nicking of that edge made reduction easy."

The Operation.—Make a longitudinal incision over the palmar surface of the prominent head of the metacarpus. As soon as the head is exposed, retract the edges of the wound and note that the anterior ligament (capsule) has been torn from its metacarpal insertion and its edge can be seen above it and close to the phalanx. Longitudinally divide or nick the capsule, and reduction becomes easy.

Frequently the capsule curls tightly over the articular surface of the phalanx in this condition. The nicking of the capsule makes it easy to pull the offending membrane out of its false position by means of hooks. Close the wound in the capsule with fine catgut. Close the skin wound. Dress. Begin movements in about one week.

In cases of old unreduced dislocations of one or other of the metacarpo-phalangeal joints, Friedrich recommends resection of the head of the metacarpus, but gives warning that pain on motion may persist for a long time.

C. C. Elliott (China Med. J., July, 1916) finds that a median incision over the palmar surface of the joint gives good access without danger to the tendons which have been pushed aside by the head of the metacarpal. A lever passed into the joint until its tip is well beneath the base of the dislocated phalanx, permits stretching of the shortened tendons, etc., so that the dislocation can be reduced.

CHAPTER CI

SYNDACTYLISM. WEBBED FINGERS

The easiest way in which to operate for webbed fingers is merely to divide the web and suture the resulting wounds. Unfortunately there always results a contraction of the wound near the root of the fingers and the condition recurs to a large extent. The following are the principal operations devised to prevent recurrence:

I. Perforate the web at its apex. Through the perforation pass a stout silver wire. Keep the wire *in situ* until the perforation is thoroughly healed when the rest of the web may be divided and the wounds sutured.

II. On the dorsal surface of the web make the triangular incision A B C (Fig. 1389) and reflect the flap A C D, which should be thick and well nourished.

Divide the web uniting the fingers. Turn the flap A C D between the divi fingers and suture the apex D of the flap to the palmar side. Either suture wounds caused by the division of the web or bring them together with adhe strips and dress with an ointment containing Scharlach red. Schre ("Zentralblatt für Chir.," 1910, No. 29) claims much for this operation.

FIG. 1389.

FIG. 1390.

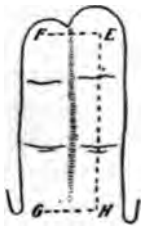


FIG. 1391.

FIG. 1392.

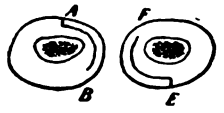


FIG. 1393.

FIGS. 1389 TO 1393.—Syndactylism.

III. **Didot's operation.**

Step 1.—On the dorsum of the fingers and web make the incisions B A ((Fig. 1390) and reflect the flap outlined.

Step 2.—On the palmar aspect make the incision F E H G (Fig. 13 and reflect the flap outlined.

Step 3.—Divide the rest of the web.

Step 4.—Make the flap B A C D envelop the finger to which it is attac (Fig. 1392) and suture it in place. Similarly envelop the other finger with flap F E H G. Figs. 1392 and 1393 are self-explanatory.

CHAPTER CII

OPERATIONS ON THE TENDONS OF THE FINGERS

Occasionally after a finger is flexed until its tip touches the palm it can c be extended by a considerable muscular effort or by the aid of the other ha "In overcoming the hitch by the action of the extensor muscles the finger spri back suddenly and usually with more or less pain." The cause of the trou is either an enlargement or nodulation of the tendon or a narrowing of tendon sheath. When trauma is the exciting cause, the lesion is usually fo in the fingers; in other cases the obstruction is almost always in the short sp between the digito-palmar fold and the first fold or wrinkle of the palm the trouble does not soon disappear under bloodless treatment annoying or disabling, operation is indicated. The princip

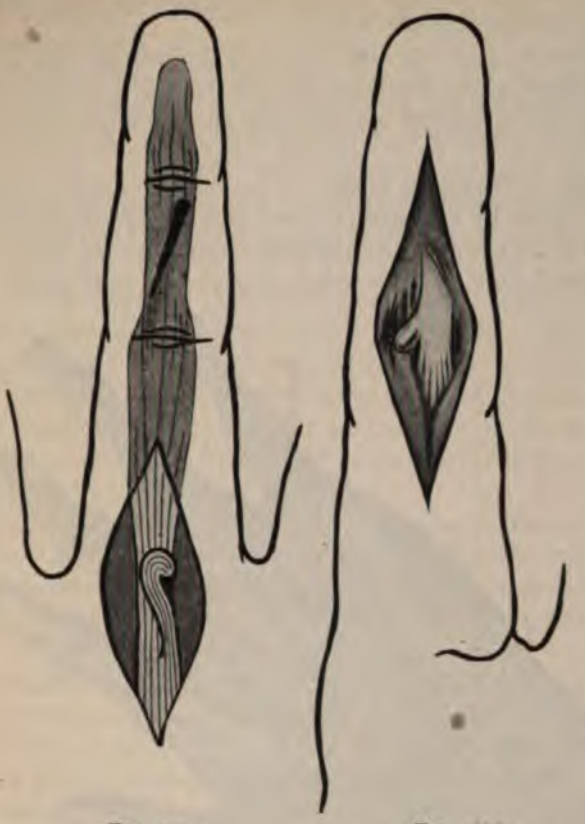


FIG. 1394. FIG. 1395.
Needle in tendon. Payer's case. Split tendon. Haegler's case.
FIGS. 1394 AND 1395.—Snapping fingers. (*Weir.*)

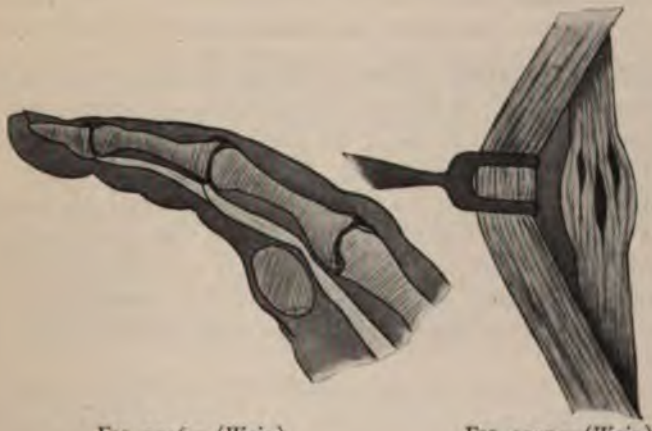


FIG. 1396.—(*Weir.*)
Tumor causing trigger finger.

FIG. 1397.—(*Weir.*)
Enlargement deep flexor.

free exposure, removal or repair of any vertical evident lesion (Figs. 1394, 1395, 1396, 1397), and closure of the wound.

When, as is commonly the case, there is a fusiform swelling of the tendon or merely a thickened sheath, Weir recommends that the sheath be split (Fig. 1398) and left open, the superficial wound being closed (Weir, "Journ. A. M. A.," Oct. 5, 1907).

Abbé considers "snapping finger" to be due to a crumpling up of the conjoined flexor tendon by a transverse band of fascia situated beneath the distal flexure crease of the palm. A longitudinal incision, about ½ inch long, through the fascia at the flexure crease is sufficient to cure in some cases.

FIG. 1398.—(*Weir from Spalteholz.*)

Tendon Transplantation.—When the flexor tendons of one or more fingers have been destroyed, *e.g.*, by necrosis due to phlegmon, function may be restored by transplantation. This is *one* of the many good things for which E. Lexer is responsible ("Archiv für klin., Chir.," xcviii, Hft. 3).

1. Obtain the graft (*a*) from a suitable tendon in a recently amputated limb (N.B.: The researches of Carrel and others show that tissues and organs may be preserved in suitable solutions, *e.g.*, Ringer's, in cold storage for days and then be successfully implanted), (*b*) from a segment of the palmaris brevis, (*c*) from a slip cut out of the rectus femoris tendon, the tendo Achillis, or any suitable and convenient source.

2. Make short incisions in the natural transverse folds at the base of the first phalanx, in the palm or at the wrist, as may be required to find the stump of the destroyed tendon.

3. Through one of these incisions introduce a strabismus hook and with it find and pick up the desired tendon stump (the flexor profundus). Separate

the tendon from acquired adhesions. With a suitable instrument introduced through the incision bore a subcutaneous tunnel to the ungual phalanx. From the side or from the tip of the finger cut down upon the end of the tunneling instrument. This cut *must* be made as a sort of flap as sufficient exposure is necessary and the wound *must not lie directly over* the implanted graft.

4. Suture one end of the graft to the tendon stump and pull the other end of the graft through the tunnel by means of an eyed probe or a thread. Suture the distal end of the graft to the periosteum of the ungual phalanx or, better, to the vivified bone itself.

5. If it is desired to replace the destroyed superficial flexor at the same time it may be accomplished somewhat similarly as follows: Find the proximal stump of the tendon and suture to it one end of a graft. Split the other end of the graft and conduct each of the two slips of the graft through the tunnel to the middle phalanx. Make a small cut on each side of the middle phalanx (preserving vessels and nerves from injury) and through these cuts suture the tendon slips one on each side to the phalanx.

6. Close the wound. Apply dressings. Begin movements on the sixth day after operation. The early motion is imperative, otherwise connective tissue penetrates and substitutes itself for the tendon which becomes a hard, immobile, fibrous mass. Unfortunately fingers requiring tendon transplantation have usually been the seat of severe inflammation and have deposits of scar tissue which in themselves cause deformity and prevent motion. In these cases preliminary operations are necessary. Thorough excision of the scar tissue and plastic repair (by skin flaps, etc.) are absolutely requisite before the tendon transplantation may be attempted.

E. Lexer reports the following case: "As the result of injury and suppuration the hand was severely crippled and entirely useless; the thumb was claw-like, immobile and flexed into the palm due to complete loss of its tendons; an extensive scar above the wrist-joint produced moderate flexion of the fingers which retained a mere trace of motion. It was necessary to resect the ankylosed first metacarpo-phalangeal articulation and produce a pseudarthrosis by the interposition of fat. Then the thumb had to be straightened by means of an H-shaped incision and the resultant defect covered with skin. Three weeks later a segment of tendon was implanted as a substitute for the lost deep flexor. This was accomplished after excision of the scar at the wrist, by tunneling through the sclerosed muscles of the ball of the thumb up to the ungual phalanx, drawing the implant through the tunnel and fixing its end to the phalanx. But as it was impossible to find the flexor tendon of the thumb above the wrist in spite of having separated all the tendons from the scar (it must have been discharged as a sequestrum), I split a slip from the flexor carpi radialis and united this to the implant. Subsequent adhesion of the other flexor tendons was prevented by surrounding and separating them with free (*i.e.*, non-pedunculated) fatty tissue. Although the result was but moderate, it was most satisfactory because of the exceedingly unfavorable condition encountered. The fingers gained one-half of their active function and could be, passively, flexed completely. Best of all the thumb remained straight and could be flexed so that its point could press firmly against the index finger."

CHAPTER CIII

OPERATIONS FOR INFECTIVE LESIONS OF THE HAND

From the standpoint of practical surgery the vast majority of standar works on Anatomy are wofully unsatisfactory in their description of the anatom of the hand. Poirier and Charpy, in their colossal "Traité d' Anatomie Hu maine," give much information regarding the tendon sheaths of the palm while Allen B. Kanavel deserves much thanks for an encyclopedic article o series of articles on the hand and its infections ("Surg., Gyn., Obstetrics.'

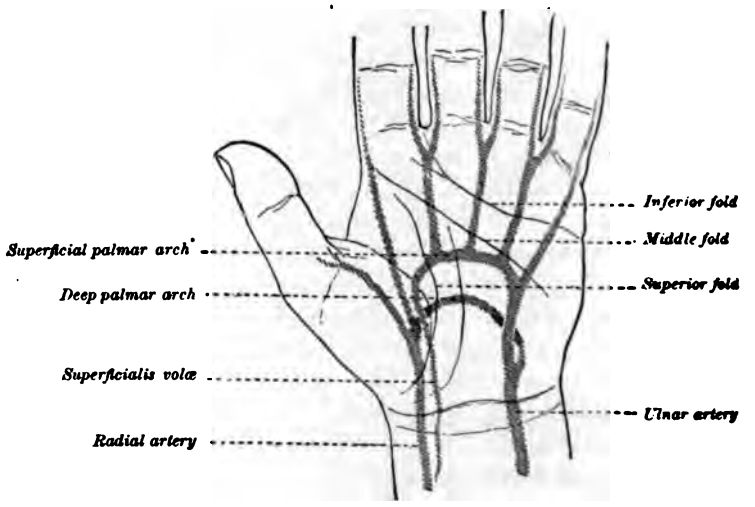


FIG. 1399.—(*Morris.*)
Relation of the palmar arches to the folds of the palm.

Sept., 1905; Nov., 1907; Jan., and Feb., 1909; "Infections of the Hand," 1912. These publications are freely used in the preparation of this chapter. In order to operate, with any degree of precision, for the relief of infective lesions of the hand a fair knowledge of anatomy is requisite.

Figure 1399 shows the position of the palmar arches.

Figures 1400, 1401, and 1402 show the usual arrangements of the synovial sheaths of the flexor tendons of the hand and how the sheaths in the fingers do or do not communicate directly with the palmar sheaths or bursæ. The synovial sac surrounding the more internal of the common flexors lies on the ulnar side of the palm and wrist (Fig. 1403). As this sac forms a pouch in front of the superficial flexors, separates the superficial from the deep flexors and forms a pouch behind the deep flexors, it may be considered as consisting of three pouches (pre-, inter-, and retro-tendinous), all opening into a common pouch— the ulnar or cubital bursa. The importance is evident of recognizing this complicated arrangement when it is necessary to drain pus from the bursa. The other palmar bursæ are not so complicated.

FIG. 1400.

FIG. 1401.

FIG. 1402.

FIGS. 1400, 1401 AND 1402.—Synovial sheaths of flexors of fingers. (*Poirier and Charpy.*)

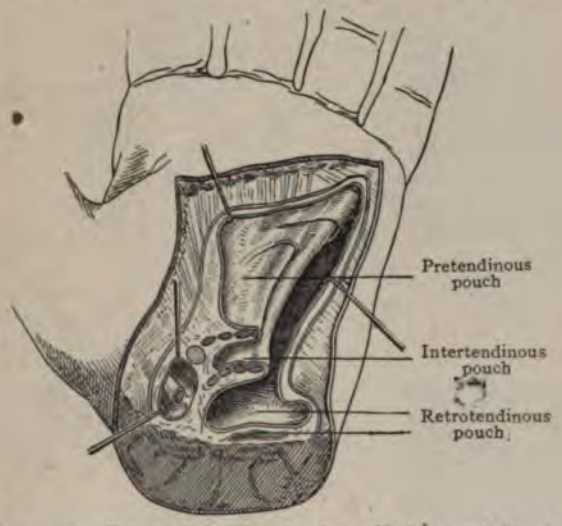


FIG. 1403.—Synovial sheaths of palm. (*Poirier and Charpy.*)

FIG. 1404.—Synovial sheaths of back of hand. (*Poirier and Charpy.*)

The synovial sheaths of the extensor tendons about the wrist are comparatively simple (Fig. 1404). Besides the synovial sheaths and bursæ there are certain well-defined, uniform spaces upon the fingers, palm, and dorsum of the hand in which pus can accumulate. A section (Fig. 1405) made through the hand 1⅜ inches (3.5 cm.) proximal to the metacarpo-phalangeal joints shows a number of these spaces admirably, while a section (Fig. 1406) taken a little higher up through the distal part of the thenar area shows another view of these same spaces. Kanavel, in a recapitulation of some of his findings, writes: "We note that we have five great spaces, with their tributaries, in which pus can accumulate.

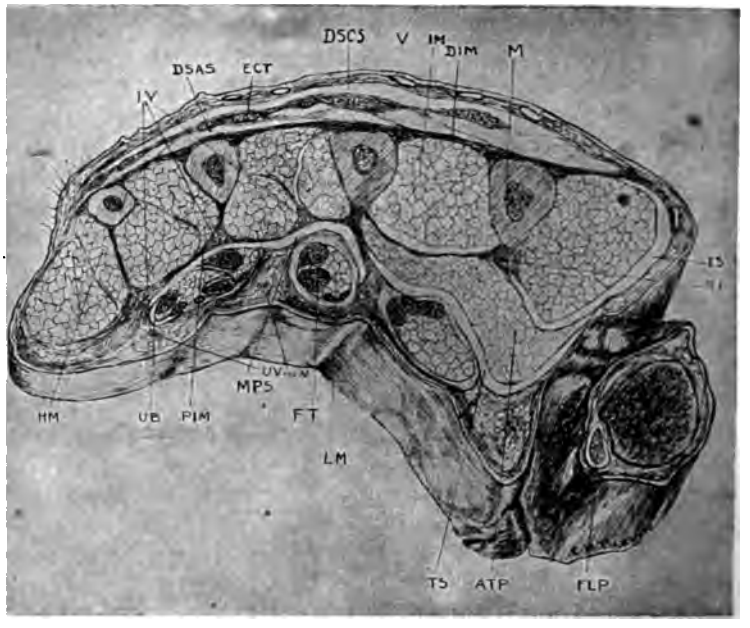


FIG. 1405.—(*Kanavel.*)

Cross section, 3½ cm. proximal to joint. SS, Synovial sheath; DSCS, dorsal subcutaneous space; DSAS, dorsal subaponeurotic space; ECT, extensor communis tendon; FT, flexor tendon; LM, limbrical muscle; IM, interossei muscle; M, metacarpal bone, HV, blood vessels; N, nerves; TS, thenar space; MPS, middle palmar space; ATP, adductor transversus pollicis; DIM, dorsal interosseous membrane; PIM, palmar interosseous membrane; UB, ulnar bursa; IS, space between adductor transversus and first dorsal interosseous; DIM, dorsal interosseous membrane; FLP, flexor longus pollicis in its synovial sheath; HM, hypothenar muscles with intermuscular spaces; IV, interosseous vessels and nerves.

"*First*, the dorsal subcutaneous, which is an extensive area of loose tissue, without definite boundaries, allowing pus to spread over the entire dorsum of the hand.

"*Second*, the dorsal subaponeurotic, limited upon its subcutaneous side by the dense tendinous aponeurosis of the extensor tendons, upon the deep side by the metacarpal bones, having the shape of a truncated cone, with the smaller end at the wrist and the broader at the knuckle. Laterally the aponeurotic sheet shades off into the subcutaneous tissue.

"*Third*, the hypothenar area, a distinctly localized space.

"*Fourth*, the thenar space, occupying, approximately, the area of the thenar eminence, to the flexion adduction crease of the thumb, not going to the wrist

FIG. 1406.—(*Kanavel.*)

Cross section, through distal part of thenar area. See Fig. 1352 for common lettering ITS, indefinite thenar spaces; TMF, tendon of middle finger; TM, thenar muscles; PF, palmar fascia; RA, radial artery; DPA, deep palmar arch—digital branches beginning; DIA, dorsalis indicis artery.

FIG. 1407.

FIG. 1408.

FIGS. 1407 AND 1408.—Sites for incisions. (*Kanavel.*)

side of the middle metacarpal. It should be remembered that this space deep in the palm, just above the adductor transversus.

"*Fifth*, the middle palmar space, with its three diverticula below along lumbrical muscles, limited by the middle metacarpal bone upon the radial s overlapped by the ulnar bursa upon the ulnar side, and separated from thenar space by a partition which is very firm everywhere except at the proxi end, where it is rather thin. A small isthmus can be found leading from proximal end of the space under the tendons and ulnar bursa at the wrist up the forearm."

FIG. 1409.—Drainage of palm. (*Kanavel.*)

Figures 1407, 1408, and 1409 show the best sites for incisions in infecti of the hand and the best route for securing drainage of the midpalmar a thenar spaces. In any case of extensive or deep suppuration of the h when operation has been decided on, it is well if possible to administer a g eral anesthetic, apply an elastic constrictor to the upper arm and oper deliberately with a precision rendered possible by a knowledge of anato and an absence of blood.

After providing for drainage, apply liberal dressings and use Bier's hyp æmia by means of an elastic constrictor. As an alternative one may evac the pus by appropriate incisions and apply hyperæmi method which has given the author very gratifying re

INCISED WOUNDS OF THE HAND must be treated on ordinary surgical principles, tendons, if divided, must be repaired and cleanliness sought. Many wounds of the hands are very much lacerated and have much dirt ingrained into them. Two methods of treatment are possible: (A) Cleanse as thoroughly as possible, repair injured tendons, close the wound, providing for drainage by means of rubber tissue. If infection develops later, treat it. Bier's hyperæmia is of much value in warding off the consequences of infection. (B) Cleanse the wound as thoroughly as possible. Swab the wound with spirits of turpentine which may act in three ways; (*a*) as a solvent of grease, (*b*) as an antiseptic, (*c*) as an excitant of local leucocytosis. Pack the wound loosely with gauze. Apply abundant moist dressings *loosely*. Apply Bier's constrictor to produce hyperæmia. Immobilize. Immobilization is of special importance to prevent spreading of infection. George Gray (who has unusual experience in the treatment of filthy lacerated wounds of the hand) treats his patients as above, and after the lapse of about forty-eight hours, if infection has not developed, removes the dressings, repairs injured tissues, and closes the wound, providing for drainage by means of rubber tissue.

Infection has entered through a wound in the finger. Suppuration has taken place. How ought the principles of treatment outlined in the preceding pages be carried out?

Make the first incision at the site of known infection. Open the tendon sheath, if involved, at the side. This applies to the middle and proximal phalanges. Do not cut the tissues over an articulation unless it is necessary to drain the joint. If necessary incise on both sides of the finger. If the infection involves the palmar end of the sheath, but has evidently *not* spread farther, incise in the middle line "from the flexion crease at the base of the proximal phalanx for about three-fourths of an inch into the palm. If, however, there is some question whether the lumbrical spaces at the side have begun to be involved the incision is made upon the side most affected, opening the space and the tendon sheath at the same time." When the index finger is affected and the infection has passed into the lumbrical space on the radial side, then it may extend into the thenar space. Under these circumstances incise so as to open the tendon sheath and lumbrical space just external to the tendon—find if pus is present in the thenar space. If pus is present continue the incision parallel to and on the radial side of the metacarpal of the index finger. This cut must run *dorsal* to the web of the thumb. Through the wound push a sinus forceps (hemostat) (Fig. 1409) across the palmar surface of the metacarpal bone into the thenar space. Open the blades of the forceps to enlarge the deep wound. Provide rubber tissue drainage. By the above means the deep palmar space is drained without the palm being incised and without danger to the palmar arches. When introducing the forceps do *not* force its point beyond the middle metacarpal, as it then would penetrate and probably infect the mid-palmar space. When the middle finger is infected and the trouble spreads upwards, the mid-palmar space becomes involved. Incise to the ulnar side of the tendon from the flexion crease at the base of proximal phalanx for about ¾ inch into the palm. If pus can be pressed from the palm into the wound pass a closed sinus forceps, at a deeped level than the tendons, so as to penetrate and provide

drainage for the mid-palmar space. It is easy to open the mid-palmar spac from the ulnar side of the flexor tendon of the ring finger by pushing a forcep upwards and inwards under the tendons (Fig. 1409).

Of course infection *may* extend from any of the fingers to the palmar synovia sheaths, but is very much more liable to do so from the little finger, whos flexor sheath is continuous with the palmar sheath (ulnar bursa) in 50 per cent of the cases, or from the thumb (Figs. 1400, 1401, and 1402), whose tendo sheath extends from the *distal* phalanx to the palmar sheath (radial bursa) an above the annular ligament of the wrist in 95 per cent. of the cases. Whe there is grave infection of the ulnar bursa very free drainage is necessary. Th following method (Kanavel's) fulfills the requirements with the minimum o injury to important structures.

Incise at the point of infection and there open the tendon sheath. Pres the palm; if it is involved, pus will come into the wound. Incise at the dista flexion crease of the palm and enter the tendon sheath. Pass a director up th sheath into the palm. Guided by the director open the ulnar bursa, cutting t the ulnar side of the tendons. "Having arrived at the anterior annular liga ment, pressure above over the prolongation of the sheath in the forearm will force pus downwards into the sheath below the ligament if the infection has extended here, as it generally has. If it is very early in the course, it may be justifiable to leave the anterior annular ligament intact and incise the sheath above the ligament on the same line. This line here lies about one-half inch to the radial side of the ulnar artery. Generally, however, the swelling is such that the pulsation of this vessel cannot be felt. It is then necessary to proceed by choosing a point at the junction of the middle and ulnar thirds of the flexor surface and incising carefully, layer by layer, until the group of flexor tendons is reached. These can be identified by moving the fingers. The dissection is now carried down along the ulnar border of these tendons in juxtaposition to them and immediately above the anterior annular ligament, since the sheath lies to the ulnar side and posterior to the tendons. If infected it should be freely opened, since the swelling due to œdema and inflammatory infiltration tends to a close small opening. If the infection is now seen to be at all severe, the anterior annular ligament is split as far to the ulnar side as possible. The hook of the unciform interferes somewhat with the incision. If it is determined at first when the palmar part is incised that the infection is at all severe, I proceed differently. The incision is continued from below upwards, at once cutting the anterior ligament and carrying the incision about an inch up on the forearm.

This latter is made as much to drain the subcutaneous area above the wrist, which commonly becomes infected, as to open the sheath. This incision is always supplemented by a transverse drainage above the wrist-joint as follows: At a point about 1½ inches above the tip of the ulna an incision is made directly down on this bone at its flexor surface; an artery forceps is now thrust across the flexor surface of this bone and the radius until it impinges on the skin at the radial side, where the knife cuts down upon it. The incisions in the skin are now enlarged to the length of an inch and a half or more and with the artery forceps, the subtendinous area to the same extent. Especial care should be used here to make the incision neither too far upon the flexor surface nor

dorsally, since in the first instance, especially upon the radial side, the artery may be injured either by the primary incision or subsequent necrosis, and in the second instance, if the incision is too far dorsal it will not drain easily. If the primary incision is made low down and on the radial side the danger of injuring the radial is greater. With the proper precaution, no anxiety need be felt (Fig. 1408). Having opened this area the finger is now inserted under the flexor profundus tendons and if there is any infection of the sheath it is bulging and can be opened easily. In case it is not found easily, flexion and extension of the fingers will locate the tendons involved and the palpating finger is pushed up among them, or an artery forceps can be pushed down from the bursa which has been opened in front. Its point is felt plainly by the finger and the opening dilated freely. As a matter of fact, the infection will be found to have ruptured into this space in practically every case, except in the very earliest stages. I wish to emphasize that it is this incision that I depend on for drainage of the upper end of the bursa, since it extends upwards on the tendons on their posterior surface. I have even made it in cases where I had made no incision upon the flexor surface of the forearm, or had deemed it inadvisable to cut the anterior annular ligament. Particularly in infections of the radial bursa do I do this. In other words, I use it as a site for entering and draining the sheath before rupture as well as the site for incision for draining the extension into the forearm."

When there is grave infection of the thumb and radial bursa, Kanavel operates as follows: "Here it is my habit to dissect down to the tendon upon the flexor surface of the proximal phalanx; having entered the sheath, the incision is enlarged along the sac through the thenar eminence separating the muscular mass (heads of the flexor brevis pollicis). It should be remembered that the tendon lies nearer the palm than one would be inclined to think, and that the mass of the thenar muscles lies to the radial side of the incision. This is only carried up to within a thumb's breadth of the lower border of the anterior annular ligament, since I have previously shown by observations made upon cadaver hands, and reported in an earlier contribution, that the motor nerve to the thenar muscles passes across the sheath between this point and the lower edge of the anterior annular ligament, and in my opinion loss of the flexor longus pollicis tendon is to be preferred to destroying this nerve, and thus bringing about a loss of the muscles which it supplies. The incision begins again at the upper part of the anterior annular ligament, opening the proximal end of the radial bursa above this ligament. If the process is severe and there is fear that the sheath may have ruptured, incisions are made laterally above the wrist-joint as described under the ulnar sheath infection and the tendon sheath drained from this site. Exceptionally incision upon the radial side alone may be sufficient. If the anterior incision is made, subcutaneous pus may be found, leading to the mistaken notion that the sheath has ruptured and is draining into this area. One should not be deterred from continuing the incision, going a quarter of an inch to the radial side of the median line of the flexor surface of the forearm. The dissection is carried down to the radial side of the flexor sublimis tendons, avoiding the median nerve in the floor and to the ulnar side. The tendon sheath has generally ruptured by this time or can be identified by

a grooved director or fine probe passed from the opened sheath below. It is entirely safe to cut the upper part of the anterior annular ligament (Fig. 1408).

If the infection has shown any tendency to be virulent or extend rapidly I feel that this anterior incision should be limited to opening the subcutaneous accumulation, if there be any, and the tendon sheath should be opened by the lateral incisions described above, for entering the space between the flexor profundus tendons and the pronator quadratus. Good-sized incisions should be made so that drainage may be free. In many cases where the infection has been severe or the tendon impaired, primary removal of the tendon should be favored. This is particularly liable to die and remain for many weeks causing the infection to persist and jeopardize other structures, so that I make it a rule if the tendon is at all destroyed or the infection shows a slow recovery to remove the tendon at once. I am also especially inclined to do this if the ulnar bursa has so far escaped involvement, since the preservation of this is particularly to be sought."

The use of drainage-tubes is to be condemned. They are unnecessary if the incisions have been properly made, and are always liable to cause necrosis of tendons. Gauze strips are useless and act as plugs preventing drainage. It is easy to keep the wounds sufficiently open by means of strips of rubber tissue or oiled silk. If these materials are not available, then gauze strips *well smeared* with vaseline or some sterile unguent will serve the same purpose. The dressings must be voluminous and *not* tight. The use of a dorsal splint is valuable. Bier's hyperæmia is an invaluable therapeutic aid and ought never to be forgotten.

CHAPTER CIV

INDICATIONS. JOINTS

It is difficult or impossible to lay down absolute rules regarding operative interference in many cases of articular disease, but a few remarks on the subject may be of value to the junior surgeon.

(A) **Wounds of the Joints.**—(See page 1030.)

(B) **Simple hydrops articuli,** generally of traumatic origin. Only if the effusion is great and resistant to treatment by pressure, etc., does it become proper to aspirate and possibly to inject some modifying fluid, such as a 5 per cent. solution of carbolic acid or 2 per cent. formalin-glycerine. If the hydrops is due to the presence of a foreign body (rice body) or its equivalent, *e.g.*, displaced semilunar cartilage, treatment must be directed against the exciting cause.

(C) **Arthritis from Pyogenic Infection.**—(I) The arthritis is not very acute; the general symptoms are not menacing in character; the general condition of the patient is good. The classical treatment is absolute rest plus some active conservative treatment, *e.g.*, Bier's hyperæmia, or puncture the joint, withdraw the fluid, douche with salt solution, and inject Murphy's formalin-glycerine solution. Watch the case carefully lest more vigorous measures may be necessary. Today arthrotomy according to Willems' principles is greatly favored.

(2) The arthritis is more acute or is accompanied by menacing symptoms, but yet the patient is not in an alarming condition.

(*a*) Open the joint sufficiently to provide free drainage, irrigate, introduce drainage-tubes to, but not through the synovialis. According to circumstances, apply suction to the parts by means of the Bier-Klapp cups (this assists drainage and provides hyperæmia) or apply Bier's rubber bandage to produce obstructive hyperæmia and hinder absorption.

(*b*) Open the joint freely. Do not irrigate. Apply light dressings. Initiate free *active* motion immediately (see p. 1031).

(3) The arthritis is very extensive and progressive. Use the Willems' treatment with very free arthrotomy. If there is so much destruction of tissue and involvement of cartilage and bone that active motion is contraindicated provide the most free drainage possible, lay the joint open as thoroughly as possible and keep it open so that no retention of discharges may be possible (Bier's obstructive hyperæmia may benefit). Do not fear injury to the subsequent function of the joint, the operation is a life-saving one and no thoughts of subsequent disabilities must be permitted to interfere with the providing of thorough drainage. Resection of the joint may be necessary.

(4) The patient's general condition is poor from age, continued disease, etc. He will be unable to withstand a long illness. Amputation is the treatment of choice. In a few cases, *e.g.*, in the hip, resection of the joint may give better prospects of recovery than amputation.

(5) The arthritis is the result of, or is complicated by, osteomyelitis. The treatment must be a combination of that for the bone lesion and of arthrotomy. Atypical or typical excision of the joint will probably be indicated.

(D) **Tuberculous Arthritis.**—The indications for treatment depend, (*a*) on the general condition and social position of the patient; (*b*) on the local lesions present.

(*a*) **The General Condition and Social Position of the Patient.**—Conservative treatment gives its best results in childhood and youth, during which periods the loss of time involved is of comparatively small importance. The old and feeble require treatment which will give the quickest possible relief with the least tax on their vitality. In youth it is more important to obtain a functionally useful joint than to save time; among the aged and debilitated prompt recovery is more important than functional recovery. The presence of visceral tuberculosis or of amyloid disease spells amputation in most instances, though to this there are exceptions. Amputation often leads to improvement, sometimes to cure, of the internal lesions.

(*b*) **Local Lesions.**

(1) **Non-suppurative Tuberculous Arthritis.**—In every case begin by using conservative treatment, *viz.*, rest with immobilization; Bier's hyperæmia; aspiration with injection of some modifying solution if hydrops is present.

If after a reasonable time (months) there is no improvement, if pain persists, if deformities develop, operation must be considered. When skiagraphy shows the presence of severe osseous lesions, conservative treatment, while it may succeed, yet is not so likely to do so. If the bone lesions do not communicate with the joint, if they can be removed without opening the joint and

without injury to an *active* epiphyseal cartilage, then it is wise to excise the diseased foci. In deciding between operative and non-operative treatment, take into consideration the individual joint affected, and the amount of handicap anchylosis of that articulation would impose on the patient.

(2) **Suppurative tuberculous arthritis** without fistula. (No pyogenic infection is present. The disease is a cold abscess of the joint.)

Combined with immobilization, *the* treatment consists in aspiration followed by injections of iodoform. (Iodoform in oil, glycerine, ether, or in formalin and glycerine.) The results obtained are better in children than in adults, because in the latter sequestra are usually present. Instead of aspirating one may incise the joint, mop it with gauze, douche with salt solution, rub the joint surfaces with iodoform or with tincture of iodine, close the wound with sutures, fill the joint cavity with iodoform emulsion before tightening the last sutures. Bier never uses iodoform injections except in tuberculous hydrops or in cases of large cold abscesses which fill the articular cavities; in these hyperæmia is out of place. Under other circumstances Bier evacuates the pus and treats by means of hyperæmia. Small multiple cold abscesses around a joint are suitable for puncture and suction hyperæmia. If improvement under conservative measures does not manifest itself in a reasonable time, or if the disease shows progress, one must resort to operation—usually typical or atypical resection.

(3) **Suppurative Tuberculous Arthritis with Fistulæ.**—This means that secondary infection is present as a complication.

(*a*) The disease is not progressing rapidly. On probing no dead or diseased bone is felt. Clean the fistula with gauze wicks or with a curette. Use suction hyperæmia. Sometimes vigorous suction may take the place of the curette. Treat the main diseases by the usual conservative means. If diseased bone is found at bottom of the fistula, this must be exposed and removed.

(*b*) Instead of treating in the preceding manner, cleanse the fistula, remove any loose sequestra, fill the fistula by injecting into it Beck's bismuth vaseline or his bismuth paste. This frequently leads to recovery.

(*c*) The above measures fail or the disease appears progressive. Symptoms are such that loss of time is dangerous. Perform either typical or atypical resection. Garré makes a valuable protest against carelessness in the treatment of tuberculous arthritis. Unless the fistulæ are kept clean and well protected by dressings, and unless the soiled dressings are sterilized or destroyed, the patient becomes a menace to the community.

(4) The presence of multiple lesions at different parts of the same limb generally demands amputation, though even here general treatment, plus local care, often leads to cure in children.

As 75 per cent. of cases of tuberculous arthritis may be cured by conservative means (Hoffa), do not lightly turn to operation. Remember that the rules guiding the surgeon in his choice of treatment vary according to the social status of the patient, his means to indulge in prolonged treatment, etc., and according to the joint involved.

(E) **Gonorrheal Arthritis.**—Conservative treatment is generally sufficient. Bier's hyperaemia is said to be most valuable. In hydrops articuli and in serofibrinous arthritis, if the above measures do not give relief pr[illegible] it is prop[illegible]

to aspirate and inject some modifying solution, *e.g.*, 5 per cent. less carbolic acid solution. In suppurative arthritis incision and drainage are necessary. Whatever means of treatment is adopted, beware of anchylosis and deformities from contracture. Remember that treatment of the seminal vesicles may be of great value.

(F) **Typhoidal Arthritis.**—It is extremely rare that typhoidal arthritis leads to suppuration; when it does then incision and drainage are necessary. Hydrops of typhoidal origin, when present, is liable to cause dislocation especially of the hip, hence aspiration is proper.

(G) **Acute Rheumatic Arthritis.**—O'Connor of Buenos Ayres, is enthusiastic over the benefits to be obtained from incision, irrigation, and drainage of whatever joints are affected. He believes that under this treatment the local lesions recover promptly, pain is relieved at once, and secondary heart troubles are avoided. The author has no experience in the matter, but O'Connor's arguments seem plausible and well backed by results.

(H) **Pneumococcal Arthritis.**—The indications are the same as in ordinary pyogenic infections of the joints.

(I) **Traumatic Dry Arthritis.**—Rovsing finds that injections of sterile vaseline exercise a favorable influence in this painful and disabling disease.

CHAPTER CV

AMPUTATION OR DISARTICULATION

Esmarch gives the following indications for amputation:

1. Extensive comminution of the bones and laceration of large vessels and nerves.

2. Extensive destruction of the whole musculature of a region even when the bones are not much damaged.

3. Very extensive destruction of skin (ulcer, burns) if the limb is rendered useless by it and repair by skin transplantation is impossible.

4. Gangrene.

5. Malignant tumors.

6. Severe septic or pyæmic infection when removal of the focus is impossible by other means.

7. Suppuration of long duration when the patient's strength is so lowered that it is evident he cannot withstand a long illness and that by amputation he is likely to recover in a short time.

8. Amputation of choice. When the patient desires to be rid of a useless organ, *e.g.*, an atrophied or paralyzed limb.

When amputation is necessitated by gangrene, when ought one to operate? Immediate amputation is called for because the patient is constantly absorbing poisons from the diseased part and is constantly losing strength. Immediate

amputation is improper because one does not know where to operate; one does not know where the gangrenous process will stop and hence too much of the limb may be sacrificed or, what is more serious, too little may be removed and gangrene may appear in the stump. It has been exceedingly difficult to decide this question in the past; if intoxication were great it was wise to run chances of recurrence and amputate; if intoxication were not severe and the patient's strength permitted, it was wise to delay until the line of demarcation became evident. Mozkowicz ("La Presse Méd.," Oct. 24, 1906) has endeavored, apparently successfully, to find where the line of demarcation will form in any given case, *i.e.*, to determine the seat of arterial obliteration. His method is the following: Elevate the limb for two or three minutes. Apply an elastic constrictor high up the limb as if for amputation and lower the limb to the table. After five minutes remove the constrictor quickly. In health the arterial circulation re-establishes itself at once, a hyperæmic flush passes down the limb and reaches the toes in about two seconds. If gangrene is present the ruddy flush rapidly passes a certain distance down the limb then pauses so that there is a clear line of demarcation between the skin above (hyperæmic) and that below (ischæmic), then the flushing passes slowly downward, taking minutes instead of seconds to reach the toes. The line where the descending flush pauses corresponds to the site of arterial obliteration and to the limit which the gangrenous process may be expected to reach. Several surgeons, notably v. Eiselsberg, have corroborated Moskowicz's observations.

Van Buren Knott, when amputating in certain bad cases of gangrene or analogous septic conditions, considers it of prime importance *first*, to be rapid, and, *second*, to avoid interference with the nutrition of the tissues to be preserved. He fulfills these conditions by making a circular amputation; dividing the skin, the muscles, the bone at the *same level*, attending to hemostasis, applying dressings and then waiting until recovery has so far taken place that it is safe to fashion the stump and divide the bone at a higher level. At the primary operation there is no reflection of the tissues, no separation of one tissue plane from another, no application of sutures and the ligatures are applied to the vessels as precisely as possible so as to avoid strangulation of surrounding structures. This method under the name "Guillotine amputation" became very popular with many surgeons during the Great War.

Fitzmaurice-Kelly ("Lancet," Jan. 2, 1915) writes that the "chief conditions calling for amputation in the present war have been compound comminuted fractures and gaseous gangrene. * * * In both a virulent infection is present and ordinary amputations are very frequently followed by recrudescence of the infection in the flaps." He advocates an operation identical with Knott's and claims excellent results provided that the nerves are pulled down and cut short. He amputates very close to the disease, even within half an inch of gangrene, and does not fear spread of the disease. In case of compound fracture of the femur, with the wounds in the groin and buttock and the fracture just below the trochanter, he amputated below the wounds enucleating the lower fragment and laying open the sinuses to the surface, with complete success. Lynn Thomas (Brit. Med. J., Oct. 7, 1916) disapproves heartily of Guillotine or "no flap" amputation preferring the circular method with two lateral incisions.

Silk or linen is objectionable for ligatures because of the dangers from sepsis. He uses catgut or silkworm gut. The flaps are pulled downwards "forming a funnel-shaped cavity in which the muscles are not in apposition." This cavity is firmly packed with gauze wrung out of Wright's hypertonic solution and in which are scattered tablets of salt as advised by H. M. W. Gray. The flaps are scattered tablets of salt as advised by H. M. W. Gray. The flaps are held together over the gauze by adhesive straps. Rubber tube drains are harmful.

John H. Gibbon, Joseph A. Blake and many others agree with Thomas in damning the Guillotine operation as favouring secondary hemorrhages, loss of time, bad stumps and re-amputations. T. G. Orr (Annals of Surg., May, 1919) from experience with returned soldiers in General Hospital 26, favours the Guillotine operation but his statistics are not entirely persuasive.

J. H. Nicoll (Brit. Med. J., Nov. 13, 1918) recognizing the frequency of secondary hemorrhage from infected open stumps after amputations recommends routine ligation of the common femoral vessels in such infected stumps of the thigh which are a week or more old. By the end of the first week after amputation the collateral circulation is ample for the needs of any stump down to the supra-condylar level. In case of secondary hemorrhage after amputation below the knee there is usually time for an attendant to apply pressure or a tourniquet until surgical aid can be obtained.

When the lesion necessitating amputation is old suppurative disease, sinuses in the tissues forming the flaps do not appear to do much harm if they are well cleaned by dissection, curettement, and chemical disinfection (H. Barnard). Recognition of this fact tends to conserbvatism.

Patients who have lost much blood bear major amputations of the lower limbs badly; when gangrenous septicæmia is a complication he outlook is very bad. Savariaud has obtained excellent results in apparently desperate cases as follows: Anesthesia by ether. Preventive hemostasis by elastic constrictor (if necessary Momberg's). After the limb has been amputated and all bleeding points clamped or tied, introduce a cannula (the cannula is conical, with an aperture of 2 mm. at its point while its base is about the size of a little finger) into the femoral vein and at once inject about 1500 c.c. of warm saline solution. The injection takes only about 2 or 3 minutes. The rapid infusion so raises the blood pressure that the small arterioles of the stump begin to bleed and can be ligated, thus lessening the danger of post-operative hemorrhage.

When and Where to Amputate a Limb after Injury.—W. L. Estes has thoroughly studied this question, his experience is vast and his ideas are well worth consideration. The following paragraphs are based on Estes's publication ("International Jour. of Surg.," June, 1905):

1. The aged and very young are intolerant of long confinement, hence are less suitable to conservative treatment than other individuals. Chronic alcoholics, diabetics, nephritics, etc., are unsuited to long-lasting conservative treatment. Tuberculosis of moderate degree does not seriously interfere with conservatism. The best subjects for conservatism are robust individuals of good habits in early adult life and children above ten years of age.

2. Severe laceration and [illegible] from falls or blows over restricted areas [illegible] more suitable for co[illegible]than when they are due to squeezes or

pressures of heavy machinery, heavy stones, or car wheels. These latter injuries correspond more or less to such as are produced by the angiotribe.

3. Thick muscular portions of a limb stand more injury than thinner parts. Crushes of bone and muscle even where extensive admit of conservative efforts if the "*skin is not fatally injured over a considerable area*, say half of the periphery of the limb at the seat of injury." If the principal vessels of the thigh or upper arm are severed and laceration is extensive, amputate. If in forearm only one system of vessels and nerves is severed, *e.g.*, the radial, and the skin is not badly damaged, try conservatism. If both radial and ulnar systems are badly damaged, amputate. The same principles apply to the leg.

4. Psychical shock due to profound nervous disturbance from fear or horror is often improved under ether, and hence immediate amputation may be performed. Anæmic shock demands treatment by means of salt solution (intravenous, hypodermic, rectal), bandaging of the extremities, warm bed, morphia, etc., and amputation must be delayed until reaction sets in, twelve, twenty-four, of thirty-six hours. Transfusion of blood is often life saving.

5. If the physical condition is not very bad, and if there is no doubt as to the necessity of amputation, do not delay.

6. When shock from the operation is much feared, then Crile's method of nerve-blocking (p. 1186) may be valuable.

7. When delay is necessary, hemorrhage must be absolutely controlled and cleanliness sought.

(*a*) Amputation is inevitable. Apply an elastic constrictor (Estes) over already injured tissues just far enough above the severed muscles and bones to assure it against slipping. The tissues compressed by the tourniquet are already so injured that they must be sacrificed and hence the extra constriction is harmless. The constrictor does not merely prevent hemorrhage; it also prevents absorption, a matter of prime importance as disinfection of the lacerated wound is usually impracticable. The constrictor should be left in place *until after* the amputation, a second tourniquet being applied at a higher level during the operation. The lacerated wound must be covered by a large moist antiseptic dressing. If in spite of these precautions infection reaches above the tourniquet, immediate operation is imperative.

(*b*) There is reasonable doubt as to the absolute necessity of amputation. Do *not* apply the elastic constrictor temporarily. Clean and disinfect the wound. Ligate vessels. Pack the wound with gauze, if desirable, placing a sheet of perforated oil silk between the gauze and the tissue to prevent adhesion. Possibly introduce one or two sutures to keep the packing in position. Apply voluminous dressings and a splint. Bandage snugly. The size of the dressings gives elasticity to the pressure of the bandage. Elevate the limb. After twenty-four to fifty-six hours proper conservative operations or amputation may be performed. Often debridement and the use of the Carrel-Dakin treatment is good.

8. If the injury affects the fingers or hand the character of the amputation will depend to some extent on the occupation or social position of the patient, *e.g.*, an irregular, "nobby" stump may be of vast service to a workman (Fig.

1410); a neat, smooth one may be far more pleasing to a fashionable lady. As a rule, in the case of the fingers, hand, and arm, as much of the limb must be saved as possible, in the case of the lower extremity several problems arise.

(*a*) The patient can afford a good artificial limb. In this case the ideas of the artificial limb-makers must be consulted. According to them the lowest favorable point for section of the bones in amputation of the leg is about 8 inches from the ground; the highest point is about four inches below the lowest edge of the patella; the lowest point for section of the femur in amputation of the thigh is about 3 or 4 inches above the knee-joint, the highest about 5 inches below the crotch.

FIG. 1410.—(*Jacobson.*)

(*b*) The patient cannot afford a good artificial limb. As much of the limb must be saved as is possible, and if possible a natural weight-bearing surface be provided for the stump as in Chopart's and Syme's amputations.

(*c*) Remember that if amputation be done through the upper third of the humerus in children, the bone left will grow and form a conical stump which may require reamputation. A warning of this fact given to the patient's guardians may save the surgeon's reputation. Conical stump is also liable to develop after amputation through the upper part of the femur in children.

9. The dangers to life are almost alike in amputations at any level of the arm and forearm. Practically all amputations below the knee are equal in safety; above the knee the higher the amputation the greater is the danger.

The Character of the Stump.—The character of the stump is of importance. As already stated, when the patient cannot obtain a good artificial limb the stump ought, if possible, to be covered with skin and tissue already accustomed to bearing weight, and the scar ought *not* to pass over the end of the bone. If an artificial limb is to be worn a number of experienced artificial limb-makers consider the best site for the scar to be directly over the end of the stump and not at the side. The prime desideratum is to have the end of the bone well cushioned with soft tissues and to have sufficient length of stump for the application of the artificial member. The osteoplastic methods of amputating are well calculated to produce good useful stumps, but are more suitable in cases when disease rather than trauma necessitates the operation.

Circular Amputation.—Circular amputation is the basis of all methods of amputating.

Example: Amputation of the arm. Place the patient on his back with the arm well out from the table. Apply an elastic constrictor around the limb near the shoulder.

***Step* 1.—Let the first as[illegible]** the skin of the arm upwards as far as [illegible]te the diame[illegible] at the point chosen for section of the [illegible]e belo[illegible] al to three-fourths the diameter of

the limb make an incision completely around the limb through the skin and down to the deep fascia. Reflect the skin and superficial fascia upwards for a distance of 1 to 1½ inches (Fig. 1411). At this level make a circular incision through all the remaining soft parts to the bone. J. N. Jackson insists that it is better to incise the deep fascia in the first cut and to reflect it along with the superficial structures from the muscles. The author agrees with him in this as the resultant stump is excellent.

Step 2.—(*a*) Make a circular incision through the periosteum at the level of the muscular wound. Reflect the periosteum from the bone for about ½ to ¾ inch upwards and divide the bone at this level. A long oval anterior periosteal flap is as efficient and is more easily made. The reflected periosteum forms flaps to cover the sawed surface of the bone.

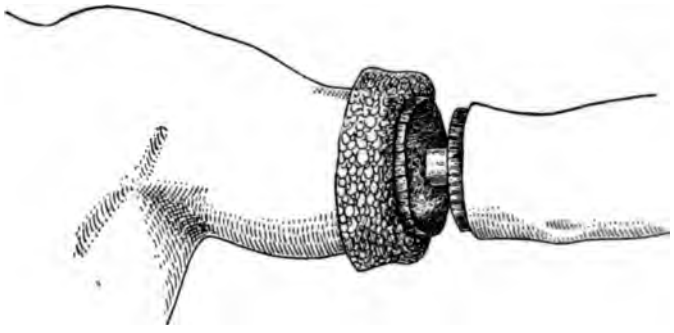


FIG. 1411.—Circular amputation.

(*b*) Separate the muscles from the bone and periosteum up to a point about ½ to ¾ inch above that chosen for section of the bone. At this level divide the periosteum and reflect it *downwards*. Divide the bone at the chosen level. The result of this is that the distal end of the bone in the stump is bare. Hirsch and Bunge find that the absence of the periosteum tends to the production of a non-tender stump. Bunge for the same purpose scrapes out the marrow near the divided end of the bone. Experience in the Russo-Japanese war showed the benefit of the Hirsch-Bunge methods.

Step 3.—Look for vessels in their normal locations and tie them. The main vessels run in the intermuscular septa, but many muscular vessels also require attention. Nerve trunks ought to be pulled out of their sheaths as far as possible and divided; this precaution often saves much after-pain. Dean Lewis finds that injection of 60 per cent. alcohol into the nerve end prevents the formation of painful neuromata.

Apply hot pads to the wound. Remove the elastic constrictor. Bit by bit remove the hot pad from the wound; pick up with forceps any bleeding vessels; ligate the vessels. Apply to the wound pads wrung out of hot water until the oozing stops.

Step 4.—Obliterate all dead spaces by means of buried catgut sutures [redacted]

relaxation sutures. Close the skin wound by sutures converting the circular into a transverse wound. If it is impossible to obliterate the dead spaces, if oozing is expected or if asepsis is not sure, provide drainage either by tube, rubber tissue, or cigarette. Apply dressing and a splint.

Crede ("Archiv für klin. Chir.," xlviii, 514) advocates the abolition of sutures after amputation. In place of them he uses a sort of capeline bandage of wide-meshed gauze, applied directly to the stump. After one or two layers of the bandage have been applied it is easy to see, through them, if the edges of the wound are in correct apposition and if the compression exercised by the bandage is too severe. Outside the bandage he applies the usual dressings.

When, owing to the conical shape of a limb, it is impossible to reflect the tissues upwards to a sufficient extent through the circular incision, it is easy to

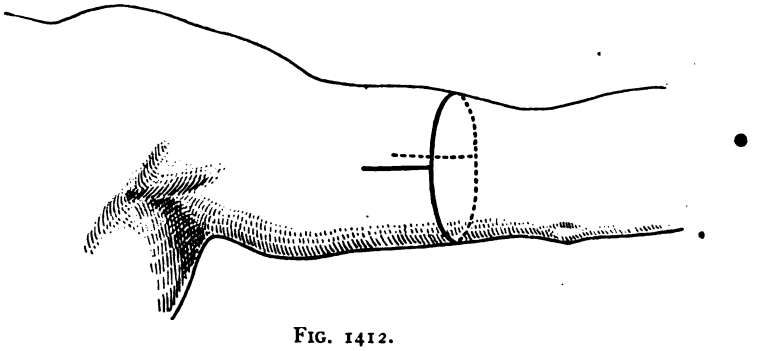


FIG. 1412.

make one or two lateral incisions through the soft parts and so facilitate the work (Fig. 1412). If, instead of making the original circular incision exactly transverse, it is made oblique, the result is an oval incision or practically an amputation by a single flap and the resultant scar is not over the middle of the stump. Thus we have the racquet incision and amputation by two equal flaps. By means of lateral longitudinal incisions (Fig. 1412) the oval amputation may be converted into one having unequal flaps.

When the surgeon desires to amputate by the flap method he of course would never dream of making the flaps in the indirect method described above, but would trace them out directly and fashion them either by cutting first through the skin and then through the musculature or by transfixion.

Amputation by transfixion is performed as follows.

Example, amputation of the lower third of the thigh:

Bring the patient so as to rest with his buttocks on the lower edge of the table. Have an assistant hold the limb well free from the table. Apply the elastic constrictor after elevating the limb to render it anæmic.

Step 1.—Retract the skin upwards. At the middle of one side of the thigh opposite the point where the bone is to be divided, pass a long amputating knife through the limb immediately in front of the femur and make its point emerge through the skin at a place directly opposite the point of insertion

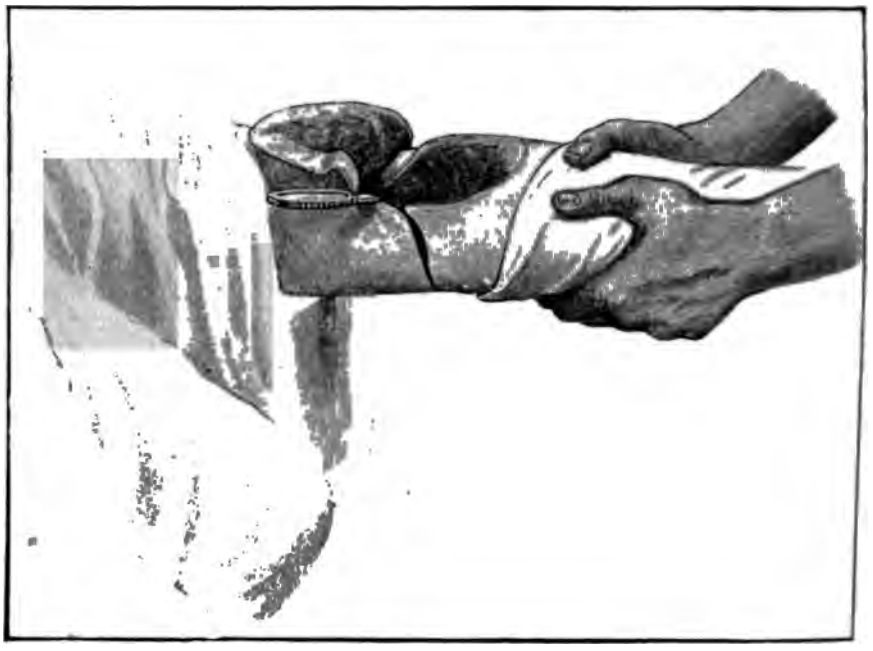


FIG. 1413.—Amputation by transfixion. (*Burghard.*)

FIG. 1414.—Amputation by lateral skin flaps. (*Farabeuf.*)

Fig. 1413). Cut downwards and forwards so as to make a flap of sufficient ength and thickness.

Step 2.—Through the original wound once more pass the knife, but make t go behind the bone. Cut downwards and backwards so as to make a posterior lap of sufficient length and thickness.

Step 3.—Retract the soft parts for a short distance up the femur. Make . circular incision so as to bare the bone at the site where it is to be divided. Divide the bone with a saw.

Step 4.—Attend to hemostasis. Close the wound as already described.

How long ought the flaps to be? They ought to e long enough to cover the end of the bone without tension, for this purpose the length of the *combined* flaps should be equal to 1½ times the diameter of the limb at the point of bone section.

A combination of methods is sometimes useful, .g., the skin and superficial fascia may be fashioned nto flaps and the deep structures divided in the circular fashion.

Example.—Amputation of the leg: Support the eg free from the table. Apply the elastic constrictor.

Step 1.—With a scalpel trace out a flap on the nner side of the leg. The incision outlining the flap egins in the middle line in front and ends at a corresponding point behind after running a horseshoe-shaped course (Fig. 1414). Beginning and ending at the same points trace out an indentical flap on the outer side of the leg. Reflect these flaps, consisting of skin and superficial fascia, upwards until their bases are reached. If the fascia lata is included n the skin flap the resulting stump is liable to be more satisfactory.

FIG. 1415.—Circular division of the muscles. (*Farabeuf.*)

Step 2.—Make a circular incision through the muscles to the bone (Fig. 1415). It is well to make he cut through the muscles posterior to the bone at lower level than that through the anterior muscles o as to allow for their greatest retraction. Divide the interosseous ligament nd the periosteum.

Step 3.—Divide the bones with a saw. Remove rather more of the fibula an of the tibia. With a saw or bone-cutting forceps remove the sharp angle rmed by the crest of the tibia. (Treat the periosteum in the manner described . circular amputation.)

Step 4.—Attend to hemostasis. Close the wound, etc.

In cases of injury the surgeon may be compelled to combine various methods suit the case. For example: The tibia and fibula are badly comminuted to a point about 6 inches below the knee; the skin, muscles, vessels, etc., are adly lacerat contused to the same level on the outer side of the leg, the parts e er side of the leg are more or less intact. The injury is

sufficient to demand amputation. There is ample amputation is performed below the knee, but none calculated to utilize the material present. In ou a long flap from the structures on the inner and gets a good result. Much may be done by ingenu to save a very useful portion of a limb which woul

In the pre-anesthetic days when haste was abso tions were especially favored as they could be spe fixing the limb with a very long knife and cutting day any limb may be amputated by means of a sc

Fig. 1416.—Retraction of muscles with three-tailed bandage during bone-section. (*Esmarch and Kowalzig.*)

2 to 3 inches long) of course, the us ceps, etc. Listo forceps are useful from the bone stu

A lion-jawed ing the end of t slice is being saw was made too low

Some surgeon bone *after* section completed, expose by a longitudinal its surroundings, Gigli wire saw, and then complete the section of t

When amputation is being performed through always easy to retract the soft parts out of dan Special metal retractors have been devised for thi bandage suffices (Fig. 1416).

It would be useless and wearisome to describe amputation.

SPECIAL AMPUTATIO

Upper Extremity.—Amputation of the Fing metrical hand is more desirable to the patient tha rule must be to preserve as much stump as possi provided with tendons.

Disarticulation of Distal Phalanx.—Flex th a transverse incision on the back of the finger into severs the insertion of the extensors. Divide t each end of the transverse incision make lateral in the phalanx to be removed. Separate the phalan palmar side (Fig. 1418) until sufficient of the so to cover stump. Divide the palmar flap transv it. Attend to hemostasis. Close the wound w scar is dorsal.

Disarticulation of Middle Phalanx.—Identical with the preceding.

Amputation through the proximal phalanx is a good operation, provided that the divided tendons are sutured to the contiguous theca (J. D. Bryant). For division of the bone of the phalanx Gigli's wire saw is preferable to bone-cutting forceps as the latter causes splintering.

FIG. 1417.

FIG. 1418.

FIGS. 1417 AND 1418.—Amputation of finger.

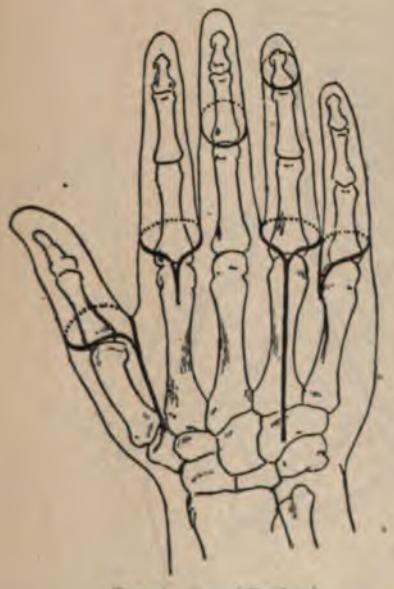


FIG. 1419.—(*Kocher.*)

FIG. 1420.—(*Veau.*)

In amputating for injury remember that any method is good which provides a well-covered useful stump.

Disarticulation at the Phalango-metacarpal or at the Metacarpo-carpal Joints.—Figures 1419, 1420, 1421, 1422, 1423, 1424, 1425, 1426, sufficiently explain these operations. Note that none of the longitudinal incisions are made in the palm.

After metacarpo-phalangeal disarticulation the resultant stump is liable to be so prominent as to interfere with the patient carrying out handiwork, a

FIG. 1421.—(*Veau.*)

FIG. 1422.—(*Veau.*)

serious matter to certain classes of mechanics. Figure 1420 shows how section of the distal end of the metacarpus overcomes this very real disability.

"When removing the metacarpus of the thumb or of the little finger it is of much importance to preserve intact the short muscles of the thenar and

pothenar eminences, because by so doing a very useful and movable stump obtained, especially if the bone is removed subperiosteally.

In disarticulating a finger, with or without its metacarpal bone, the transerse incision follows exactly the line of the web of the fingers; incisions must ot be made higher up in the palm" (Kocher).

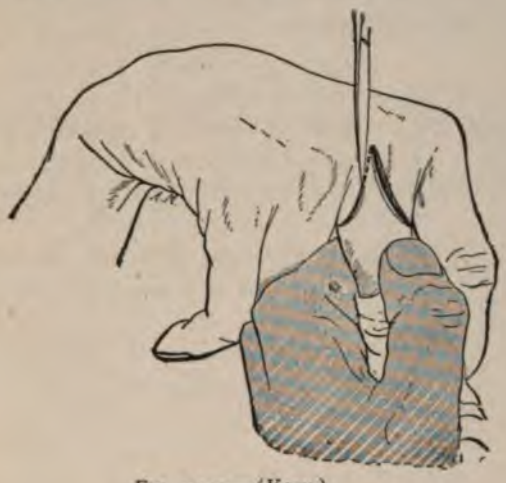


FIG. 1423.—(*Veau.*)

FIG. 1424.
(*Esmarch and Kowalzig.*)

FIG. 1425.
(*Esmarch and Kowalzig.*)

FIG. 1426.
(*Esmarch and Kowalzig.*)

Amputation at, or Disarticulation of the Wrist.—Do *not* make a typical mputation here if it is at all possible to save a portion of the hand or a movable nger.

Kocher recommends an obliquely circular (oval) incision so as to form a almar flap (Figs. 1427–1428). Figures 1429–1430 show a method named fter various surgeons (Poupart, Dubrueil, v. Walther).

Amputation through the Forearm Requires no Special Notice.

Disarticulation of the Elbow.

(A) **Circular Incision.**—(1) Make a circular cut through the skin a superficial fascia about 2 inches below the condyles of the humerus. Refle the skin upwards so as to expose the joint.

(2) Strongly extend the joint. Open the joint by a transverse incision front. Divide the lateral ligaments.

FIG. 1427.

FIG. 1428.

FIGS. 1427 AND 1428.—Kocher's method.

FIG. 1429.—(*Esmarch and Kowalzig.*)

FIG. 1430.—(*Esmarch and Kowalzig.*)

(3) Hyper-extend the joint until the olecranon projects into the wound Divide the tendon of the triceps at the tip of the olecranon. Attend to hemo stasis. Close the wound.

(B) **Kocher's Method.**—(1) Flex the elbow to an angle of 135°.

(2) Make an obliquely circular (oval) incision round the limb (Fig. 1431) Anteriorly the incision is at the joint level (*i.e.*, just above the level of th head of the radius), posteriorly it is a hand's breadth below the tip of th olecranon.

Estes justly criticises this incision by saying, "the soft tissues of the anterior surface contract very markedly, those of the posterior not at all or very little, so that a circular incision at the elbow will become by the contraction of the tissues an oval one with a long posterior flap; it is necessary to bear this fact in mind so that the posterior flap may be made sufficiently long."

(3) Reflect the posterior flap, consisting of skin, fascia muscle and periosteum upwards to the posterior surface of the humerus.

(4) Divide the ligaments. Remove the limb.

(5) Close the wound after attending to hemostasis.

(C) **Farabeuf's operation** is similar to Kocher's but he obtains his main flap from the front instead of from behind.

Amputation of the Arm Requires no Special Comment.

Amputation at the Shoulder-joint (Disarticulation).—Methods of attaining hemostasis before dividing the vessels:

(*a*) Pressure by finger or padded key, on the subclavian artery. This is unsatisfactory as movements of the shoulder, necessary during the amputation, are likely to interfere with its success.

(*b*) An elastic constrictor applied above Wyeth's pins, introduced as in Fig. 1432. This method acts admirably. If the vessels are caught in forceps *before* the joint is disarticulated it is always efficacious.

(*c*) Preliminary ligation of the subclavian artery is valuable in case of large, vascular tumor about the head of the humerus.

If the surgeon and his assistant use their brains as well as their hands, it is easy to control hemorrhage in the course of the operation. A glance at Fig. 1433 shows the principal arteries which will be encountered.

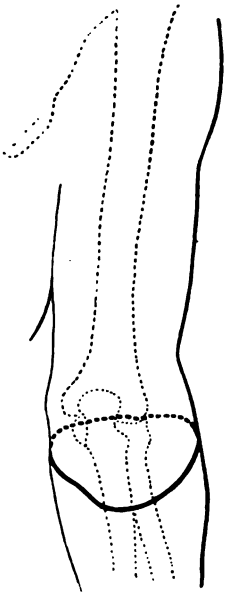


FIG. 1431.—Kocher's amputation at elbow.

(*d*) Pass an elastic constrictor round the shoulder behind or proximal to the coracoid and acromion processes. To prevent slipping, pass a loop of ordinary bandage under the constrictor and have an assistant pull this towards the opposite shoulder. This is a very efficient method.

Jacobson mentions that there are about thirty-two methods for disarticulating at the shoulder. Only a few types will be described here. Remember that when there is much laceration of the shoulder the stump may be covered by any available viable skin and give a good result.

Remember also that it is imperative when amputating for malignant disease, to sacrifice too much rather than too little, and that if all the tissues which are usually employed to cover the stump have been removed, it is easy to obtain the necessary tissue in the shape of flaps taken from the chest.

Hold the arm at right angles to the chest.

The apex of the axilla make a 4-inch longitudinal incision

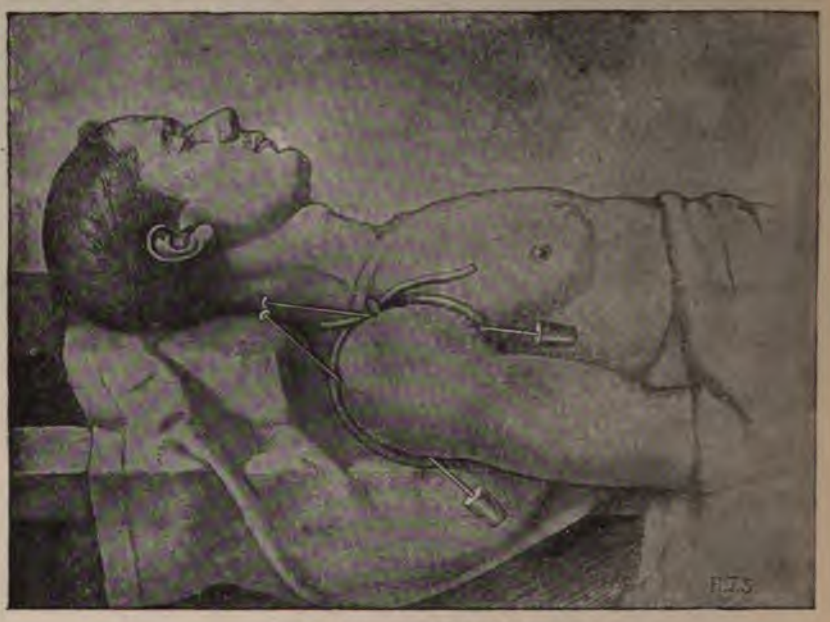


FIG. 1432.—(*Wyeth.*)
Shoulder-joint amputation. Pins and rubber-tube tourniquet in position.

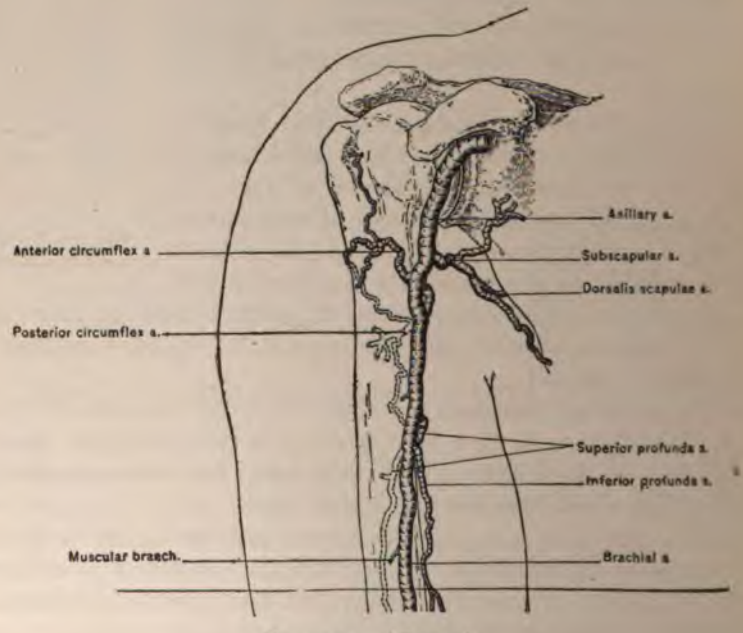


FIG. 1433.—(*Deaver.*)

down the arm immediately behind the anterior wall of the axilla along the inner and posterior border of the coraco-brachialis (Fig. 1434). Elevate the pectoralis major and under it divide the deep fascia so as to expose the coraco-brachialis. Pass the finger between the coraco-brachialis and the packet of axillary vessels and nerves.

Separate the vessels (artery and vein) from the nerves and divide them (the vessels) between ligatures. Pull the nerve trunks downwards and divide them high up.

Step 2.—At right angles to the original incision make a circular cut down to the bone all round the arm at the level of the insertion of the deltoid. Separate the soft parts from the bone up to its head. Disarticulate.

Step 3.—Review the wound. Trim away redundant tissue. Suture. Dress.

FIG. 1434.—Amputation at shoulder.

Method B.—Spence's operation or racket method.

Step 1.—Slightly abduct arm. Rotate humerus outwards. Beginning immediately external to the coracoid process make an incision downwards to the insertion of the pectoralis major, which is cut. This cut divides the clavicular fibres of the deltoid and the pectoralis major. Continue the incision in a curve round the outer side of the arm to the posterior fold of the axilla. The incision penetrates to the bone, dividing the lower part of the deltoid.

Step 2.—Make a similar incision round the inner or axillary side of the arm, *but only divide the skin and superficial fat.* This inner incision does not reach such a low level as the outer one.

Step 3.—Separate the outer flap from the bone and joint. Retract the flap upwards and backwards together with the trunk of the posterior circumflex, thus exposing the head and tuberosities of the humerus.

Step 4.—Cutting directly on the tuberosities and head of the humerus, divide the tendinous insertions of the capsular muscles. By thorough retraction of the outer flap and by hugging the bone with the knife injury to the posterior circumflex artery is avoided; this is important as, if punctured, this artery is not easy to pick up with forceps and its obliteration endangers the nutrition of the deltoid and skin (Treves).

Step 5.—Let the assistant who is holding the arm so manipulate it that the head of the humerus is thrust upward and outward to project well above the glenoid cavity. Grasp the head of the bone and pull it outwards. Hugging the inner side of the bone, cut the posterior part of the capsule. The arm is now connected with the body by the axillary tissues alone. Let the assistant grasp these tissues with his hand so as to control the vessels they contain. Instead of the fingers a gastroenterostomy clamp may be used for this purpose. Divide the axillary vessels along the line marked in Step 2.

Step 6.—Ligate the vessels. Cut the axillary nerves short. Close the wound. J. Hutchinson, Jr., advises that all synovial membrane be excised as a discharge of synovial fluid sometimes delays union.

Method C.—Amputation by Superior and Inferior Flaps.—Bring the patient to the edge of the table. Raise the arm enough to relax the deltoid.

Step 1.—Lift the deltoid with the left hand. Pass a long, narrow, strong knife from a point just below the coracoid process under the deltoid and close to the anatomical neck of the humerus, to emerge at a point a little *below* the most prominent part of the acromion. (The transfixion may be accomplished in the reverse direction equally well.) After transfixing, cut downwards and outwards so as to make a rounded flap well down to the insertion of the deltoid.

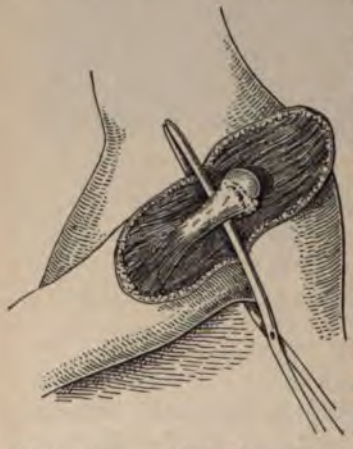


FIG. 1435.—Control of vessels in shoulder amputation.

Step 2.—Reflect the flap. Expose the joint. Divide the capsule by cutting on the head of the bone. Vigorously rotate the arm outwards and divide the subscapularis and biceps. Rotate the arm inwards and carry it across the chest so as to expose and divide the muscles attached to the great tuberosity.

Step 3.—Dislocate the head of the bone. Divide the capsule behind the head of the humerus. Grasp the undivided structures firmly in a gastroenterostomy clamp; this controls the axillary vessels (Fig. 1435). Slip the knife behind the head of the bone. If the clamp has not been applied as above, have the assistant grasp the soft parts to be divided *behind* the knife. Cut along the shaft of the humerus and make an inferior flap half the length of the superior. The rest of the operation is the same as in Method B.

Method D.—Furneax Jordan's Method.—Apply an elastic constrictor high up. Divide the soft parts down to the bone, as in circular amputation, 3 to 4 inches below the axilla. Secure the vessels. Make a longitudinal incision along the outer and posterior aspect of the limb at right angles to the circular cut. Remove the bone. This method is capable of many modifications and may be carried out after arthrotomy has shown that the limb cannot be saved. The same may be said of Spence's operation.

In operations for malignant disease in the aged or in the presence of pro-

found depression or shock, Crile blocks the nerve trunks and operates under regional anesthesia.

Crile's Method in Shoulder Disarticulation (Problems Relating to Surgical Operations, Crile, 1901):

Step 1.—Under infiltration with 1/10 per cent. cocaine solution. Make an incision along the outer margin of the sternomastoid just above the clavicle. Divide the deep fascia.

Step 2.—Retract the omo-hyoid downwards, the anterior margin of the trapezius backwards, the posterior margin of the scalenus anticus forwards

FIG. 1436.—Crile's disarticulation of shoulder. (*Crile.*)

(Fig. 1436). This exposes the trunks of the brachial plexus and by extending the dissection a trifle downwards the arching subclavian artery is seen. When dissecting look out for small nerve twigs in the connective tissue planes or accompanying blood-vessels. Anesthetize such nerves before dividing them.

Step 3.—Inject each nerve trunk with just sufficient cocaine solution (1/2 per cent.) to cause a localized swelling. The injection is made first into the outer covering, then into the substance of the trunk.

This "blocking" causes complete loss of sensation and motion in the parts supplied by the brachial plexus.

Step 4.—Apply Crile's clamp with blades protected by rubber tubing, to the subclavian artery.

Step 5.—Amputate by one or other of the methods described. Note that cuts on the outer and posterior aspects over the deltoid should be made low down to avoid skin supplied by the cervical plexus.

Interscapulo-thoracic Amputation.—J. William White finds that the mortality after this operation is not more than 10 per cent., probably 6 per cent., and that about 20 per cent. of the patients who survive operation remain well after three years. The indications for interscapulo-thoracic amputation are (*a*) extensive injury; (*b*) malignant disease of the humerus or shoulder-joint; (*c*) Lund has done this operation for sarcoma of the brachial plexus otherwise irremovable.

Berger ("Revue de Chir.," Oct., 1898) considers that disarticulation at the shoulder does not give sufficient guarantee against recurrence of malignant

FIG. 1437.—Interscapulo-thoracic amputation.

Photograph taken a few days after operation. Note the numerous scratches and shallow incisions made to prevent stagnation of fluids in the flaps which were under considerable tension. As shock was severe the wound was hastily closed hence the imperfect skin coaptation. Union was perfect in about three weeks. When seen three years later the patient seemed well.

neoplasms of the upper end of the humerus. When recurrence takes place after disarticulation, the disease propagates itself along the scapulo-humeral muscles. Interscapulo-thoracic amputation removes *en masse*, these routes of dissemination; it further so opens the axilla as to discover enlarged glands which would otherwise escape detection.

The only reservation Berger makes to the above doctrine is the following: Some relatively benign tumors of bone do exist (giant-cell sarcomata; chondromata; myxomata perhaps) and recovery may follow a limited resection, *i.e.*, excision of the tumor itself. To justify a conservative operation, the tumor must be clearly circumscribed and encapsulated; there must be no prolongation either along the muscles or into the shoulder-joint; microscopical examination of a segment of the tumor, made at the time of operation, must verify the diagnosis of the exact nature of the neoplasm.

Le Conte's Method.—Le Conte ("Congrès International de Médicine," 1900) gives an admirable account of the operation as performed by himself. It is as follows:

1. The incision begins over the sternal end of the clavicle, is carried along that bone to about its middle, and then curved downward to the anterior axillary fold. The skin and superficial fascia are dissected up, exposing well the inner two-thirds of the clavicle.

2. The clavicle is disarticulated by severing its attachments to the sternum and the rhomboid ligament; the clavicular attachment of the sterno-cleido-mastoid muscle is cut close to the bone, and the clavicular portion of the pectoralis major is separated with the finger from the costal portion of the muscle up to the anterior axillary fold.

3. The clavicle is now pulled upwards and forwards, and the attachment of the subclavius muscle is divided at the first rib. The pectoralis minor will now be well exposed, and it is divided and the coracoid portion reflected upwards with the clavicle. This exposes the axilla fully, and the vessels are seen traversing it from the anterior scalenus muscle down.

4. The sheath of the vessels is opened and the vein separated from the underlying artery. Two ligatures are passed, about 1 inch apart, around the artery and tied. The arm is then held up to empty it of blood, while two ligatures are passed around the vein, but these are not tied until the arm is blanched. This renders the use of an Esmarch bandage unnecessary. It must be noted that the cephalic vein has joined the axillary below these ligatures, or else a separate ligature of that vessel is required.

5. The vessels are now severed, together with the brachial plexus of nerves and the costal portion of the pectoralis major. This completes the division of the anterior attachments of the arm.

6. A posterior incision is now carried from some point on the anterior incision (as near the tumor as it is deemed advisable to go) directly backwards and downwards to the inferior angle of the scapula and up again to the posterior axillary fold. The skin and superficial fascia are dissected up for a short distance.

7. The trapezius is severed and the transversalis colli or posterior scapular artery secured; the omo-hyoid muscle is cut and the supra-scapular artery secured, and the muscles attached to the inner border of the scapula are rapidly divided close to the bone. Then, the serratus magnus and latissimus dorsi are cut, the latter at the posterior axillary fold. The arm is now held to the body by the skin of the axilla alone. If there is sufficient flap to cover the wound, the anterior and posterior incisions are joined through the axilla, but if more skin is needed, a flap may be raised from the under surface of the arm. The wound is then closed with suitable provision for drainage.

Figure 1437 shows the appearance of the wound in a patient operated on by the author.

Figures 1438 and 1439 show how Lynn Thomas uses his forceps-tourniquet in interscapulo-thoracic amputation.

Crile's Method.—Under general anesthesia make an incision over the clavicle and resect the inner half of the bone so as to expose the subclavian vein

and the trunks of the brachial plexus. Inject each nerve trunk with a ½ per cent. solution of cocaine or eucaine; this "blocks" them. Divide the brachial plexus. Ligate the subclavian artery and vein. During the rest of the operation (already sufficiently described) "the amount of shock will be limited to what would be produced by making the incision through the structures supplied by the nerves from the cervical plexus, which is almost *nil*."

FIG. 1438.—Lynn Thomas' forceps-tourniquet. (*Thomas.*)

Le Conte recommends the disarticulation of the sternal end of the clavicle in preference to a resection of the middle portion of that bone, for the following reasons:

1. It gives the widest and fullest possible exposure of the vessels and decreases the accidents of ligation to a minimum.

2. It insures the securing of the artery first, before the vein is tied, enabling one to elevate the arm and make a practically bloodless amputation.

3. The disarticulation is simpler and quicker than resection of the bone, and ıere is less danger of wounding important vessels.

4. The suprascapular and posterior scapular vessels, the only other vessels ıat can bleed, are easily picked up before being cut.

5. In malignant growths, where the outer end of the clavicle is involved, ıere is more hope of a radical cure if the entire bone with its periosteum is moved.

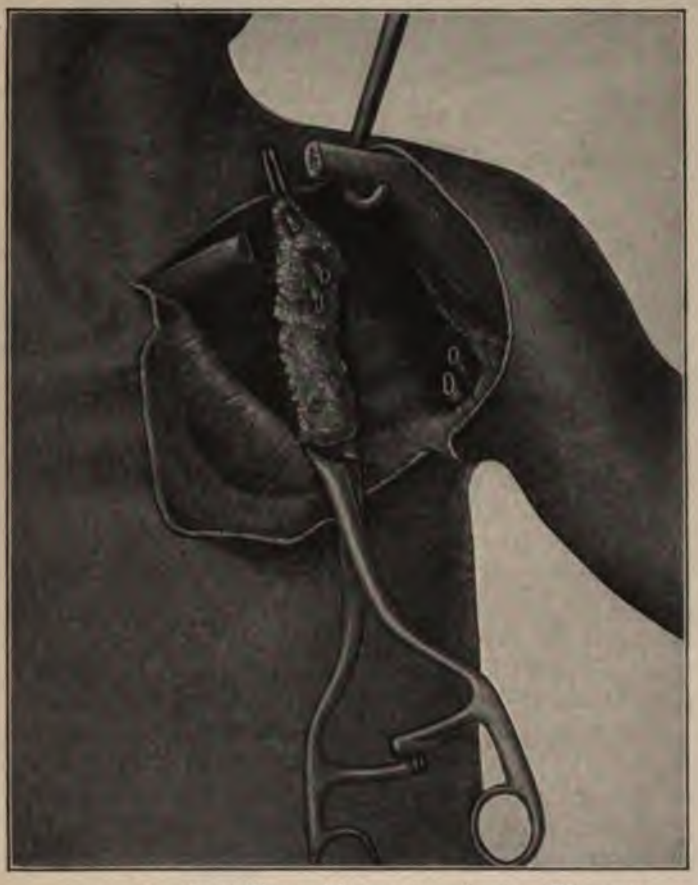


FIG. 1439.—Lynn Thomas' forceps-tourniquet. (*Thomas.*)

6. It removes everything in one piece, a more surgical procedure when ealing with malignant growths.

Cinematic or Cineplastic Amputations.—Vanghetti's Amputation.—Vang-ɛtti's experiments on birds show that if a tendon or muscle is separated from s insertion and some inches of its distal end are mobilized and covered with ɛin, the muscle retains its power of voluntary contraction. If the distal end f the tendon is formed into a loop or into a knob (*e.g.*, by being tied as a knot ıd is covered with skin, it is possible to attach a hook or a string to it, and

by means of that hook or string to convey the power, provided by the muscle contracting, to a proper artificial limb. These were remarkable experiments to be made by a country practitioner without hospital connections. Vanghetti has published a small volume "Vitalizzazione delle Membra Artificiali" (Hoepli Milan, 1916) on the subject of cinematic amputations.

The method of application devised by Vanghetti is somewhat as follows: In performing an amputation preserve as great a length as possible of any healthy tendons or muscles distal to the line of section of the bone. Form the ends of these tendons (*a*) into loops either by suturing the extremities of two tendons together, or by folding the extremity of one tendon on itself and fixing it as a loop by means of a suture; (*b*) into a knob by tying the end of the tendon into a knot. In the case of a muscle or even a tendon, instead of being divided, a portion of its bony insertion may be chiselled off its bed and left attached to the tendon or muscle as a knob. Envelop the mobilized tendon or muscle (including the loop or knob at its end) with a flap of skin. If a loop is used perforate the skin so as to pass a smooth hook (as an ear-ring) through the loop and by means of this hook and a proper splint keep up enough tension on the tendon to prevent secondary contraction. If the tendon is fashioned as a knob it is unnecessary to perforate the skin, a padded ring may be made to lie around the skin-covered tendon proximal to the knob, and by means of this ring the necessary tension may be kept up. De Francesco ("Archiv für klin. Chir.," lxxxvii, p. 571) carried out Vanghetti's ideas in the case of a man who had undergone amputation in the middle of the forearm five years previously. The muscles in the stump retained their electric irritability and could be contracted voluntarily.

FIG. 1440.—Cinematic apparatus.

De Francesco made a longitudinal incision on each side of the forearm and through them exposed the radius and ulna from a point about ¾ inch proximal to their distal ends, upwards for about 2 inches (5 cm.) (Fig. 1440). He divided the bones ¾ inch from their distal end and at points 2 inches higher, thus removing about 1 inch of each bone. When healing took place, a padded ring was applied around the stump just above the two fragments of radius and ulna, and after a little practice the patient was able to voluntarily flex the fingers of an artificial hand by means of cords attached to the padded ring. The power was obtained by the flexors and extensors pulling upward the knobby stump and with it the padded ring (Fig. 1441 shows De Francesco's patient enjoying himself).

Vrédène (Roussky Bratch., ref. "Journ. de Chir.," i, No. 2) used Vanghetti's method successfully in a case of amputation of the hand just in front of the carpus. The superficial flexor tendons of the hand, exposed through an incision in the lower part of the forearm, were divided transversely at the lower part of the wound, and their proximal stumps sutured to the deep flexors (Fig. 1442).

The tendon loop can readily be enveloped in skin flaps, the pedicles of which may be divided after the lapse of about two weeks. In Vrédène's case exercises

were begun after about one month, and the tendon loop was able to exert a pull of 12 pounds. An artificial hand was constructed and its movable thumb, middle

FIG. 1441.—Result of cinematic amputation. (*De Francesco.*)

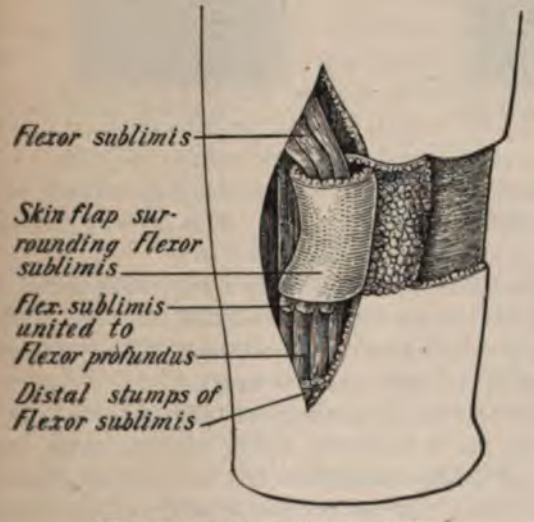

Flexor sublimis
Skin flap surrounding Flexor sublimis
Flex. sublimis united to Flexor profundus
Distal stumps of Flexor sublimis

FIG. 1442.—Cinematic amputation.

FIG. 1443.—(*Ashhurst Annals Surg.*)

and index fingers could be flexed by means of the tendon loop to which they were connected by a metallic hook. The patient was able to seize and hold various objects.

In the above description the tendons of the flexor profundus are not divided, but probably their division below their union with the flexor sublimis would give greater mobility. Ashhurst (Annals Surg., Dec., 1914) operates on the arm as follows:

Step 1.—Reflect a longitudinal skin flap as long as the diameter of the limb and about one inch wide, with its base at the proposed line of section of the bone. Ligate and divide the brachial vessels just above the site of bone section. Divide the nerves at the same level or higher, Fig. 1443.

Step 2.—Make a longitudinal incision on the outer side of the arm between the flexor and extensor muscles and raise these muscles from the bone along with the skin from the line of bone section down as far as possible. Now divide the musculo-spiral nerve if it was not accessible from the first incision.

Step 3.—Divide the soft parts circularly down to the bone at the lowest limit of healthy tissue. Thus two musculo-cutaneous flaps are formed and reflected (one flexor flap, and one extensor flap).

FIG. 1444.—(*Ashhurst, Annals Surg.*)

FIG. 1445.—(*Ashhurst, Annals Surg.*)

Step 4.—Divide the bone at the selected point and remove the limb.

Step 5.—Make a small transverse incision through the skin on each side of the upper end of the external longitudinal incision. This permits the skin of each flap to be wrapped round the corresponding muscles.

Step 6.—Cover the end of the bone with the skin flap made in Step 1. Suture the end of the flexors to the end of the extensors and suture the end of the skin surrounding the flexors to that surrounding the extensors. Pass a rubber tube through the loop thus formed. (Figs. 1444 and 1445.)

Cinematic amputations have lost much of their desirability since Carnes devised his artificial arms, by the use of which the author has seen a man, who had lost both arms, pick coins off the floor, light his cigar with matches, shave himself and carry a heavy suit-case. One patient whose arm was amputated above the elbow by the author, drives his own electric motor car.

Krukemberg in 1918 described an amputation of the forearm in which the radius and ulna were separated for $\frac{2}{3}$ of their length and thus formed a grotesque pincers. Unfortunately the efficacy of the "pincers" was low because while there was sufficient muscular power to strongly separate the jaws, there

was too much destruction of the muscles capable of approximating the jaws. The grotesqueness of the stump tempted the patient to conceal rather than use the "pincers."

Putti and Lambert (Tuffier, Bul. et Mem. de la Soc. de Chir., Paris, Feb. 10, 1920) modified Krukemberg's operation as follows:

From a point about 8 or 10 cm. (3¼ to 4 in.) above the end of the stump and well to the radial side of the mid-line, make a longitudinal incision on the anterior surface of the forearm through the skin downwards to the distal extremity of the stump. Make a similar incision on the posterior surface of the forearm, but let this incision lie well to the ulnar side of the median line of the limb. Join the distal ends of these two incisions by a transverse cut crossing the extremity of the stump. (It is assumed that the operation is secondary to an old amputation.) Reflect the skin sufficiently to form two flaps exactly as in Didot's operation for syndactylism (p. 1128). If the ends of the radius and ulna are united by bone, excise the osseous union.

With retractors pull the radius and ulna apart. Along anatomic lines divide longitudinally the deep and superficial layers of muscles and tendons. Divide the pronator quadratus and the interosseous membrane. The flexor carpi radialis and parts of the flexors are thus left attached to the radial "finger" of the stump, while the remainder of the flexors belong to the ulnar "finger." It is necessary to cover the radial and ulnar fingers or stumps separately with skin; to render this possible cut away all superfluous muscle very freely, as the only difficulty in the operation is the obtaining of enough skin. In one case Lambret was obliged to insert an Italian graft at the inter-radio-ulnar commissure to insure the greatest possible mobility.

The result of the operation is a bifid stump, the radial branch of which is mobile. With the stump the patient is able "to hold a spoon, a pencil, as well as to select and extract any object from his pocket." The main advantage of such a prehensile stump over any artificial hand consists in its sense of touch. If an artificial hand is worn, rotation is easy.

AMPUTATIONS AND DISARTICULATIONS OF THE LOWER EXTREMITY

Amputations and Disarticulations of the Toes.—These are carried out exactly as in the case of the fingers. When the great toe is disarticulated at the metatarso-phalangeal joint, remember that the great size of the head of the metatarsal bone requires large flaps to cover it and that in the presence of articular suppuration the sesamoid bones ought to be removed.

König writes: "When operating for injury or disease of the anterior part of the foot, and it is in any way possible to retain the tarso-metatarsal articulations, limit operation to amputation through the metatarsus. A sufficiency of material must be present since the stump must be covered by a plantar flap and the scar must be dorsal. The amputation is performed exactly like Lisfranc's disarticulation except that the metatarsi are divided. We have often remarked that too great conservatism is out of place in the foot. Thus it is questionable if it makes much difference to the patient

whether the metatarsus hallucis is amputated or exarticulated. T
of the two middle metatarsi makes little difference to the patient,
verse amputation is always better than the removal of three met

Tarso-metatarsal Disarticulation.—Lisfranc's Amputation.—*St*
the foot in a position of plantar flexion. Note the base of the first
fifth metatarsal bone (Fig. 1446). On the *dorsum* of the foot make
A B C down to the bone and reflect *all* the soft parts so as to expos
metatarsal articulations freely.

Step 2.—Put the foot in a position of dorsal flexion. On the *sole*
make the incision A D C and reflect all the soft parts in one long
until the articulations are exposed.

Step 3.—Hold the foot in a position of marked plantar flexio
both flaps, being specially careful of the plantar flap. Carry the k
and narrow-bladed) round the base of the fifth
then cut forward and inward to open the joints
outer metatarsals. Next open the joint betwee
metatarsal and the internal cuneiform. Holdi
firmly, insert it between the first two metatarsa
it backwards and forwards in the long axis
(Fig. 1447). Do the same between the second
metatarsals. Open the joint between the second
and the middle cuneiform. Complete the disa
Jacobson wisely writes: "The method by dis
may be a useful test of a candidate's knowledge
an examination. In practice, sawing through
tarsals just below their bases may nearly alwa
stituted, as giving equally good results with a g
of time and trouble."

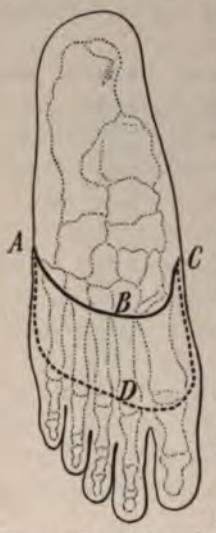


FIG. 1446.—Lisfranc's amputation.

Step 4.—Attend to hemostasis. Close the
sutures. Dress.

The great objection to Lisfranc's operation i
projection of the internal cuneiform and scap
makes a stump which is likely to be painful.

Hey's Amputation.—The author has no experience with the ope
Estes recommends it as much preferable to Lisfranc's. Barker thu
Hey's amputation: "Position of Patient: Supine, with the legs br
over the end of the table, the affected limb being flexed, and resting o
the edge of the table. The surgeon stands facing the patient; a
steadies the flexed limb, on the outside of which he stands facing th

Landmarks for Incision and Operation.—The bases of the firs
metatarsal bones are the guide for the first incision, which passes w
downward curve from one to the other, across the dorsum of the foot
flap which should reach well over the metatarsus and contain all the s
When this is turned up the operator separates the metatarsus from th
forcibly bearing upon the former while the heel rests on the table, a
the tense ligaments, remembering the deep setting of the second metat
The knife is placed transversely behind the metatarsus as the latte

forward by the surgeon's left thumb, and is made to cut downward to the roots of the toes. The long plantar flap thus formed is now cut across, either from side to side or by transfixion from its centre, first on one side, then on the other, the knife being held vertically in each case. It should be a little longer on its inner than on its outer side. Some operators prefer to fashion the plantar flap before separating the bones. Others again recommend cutting through the

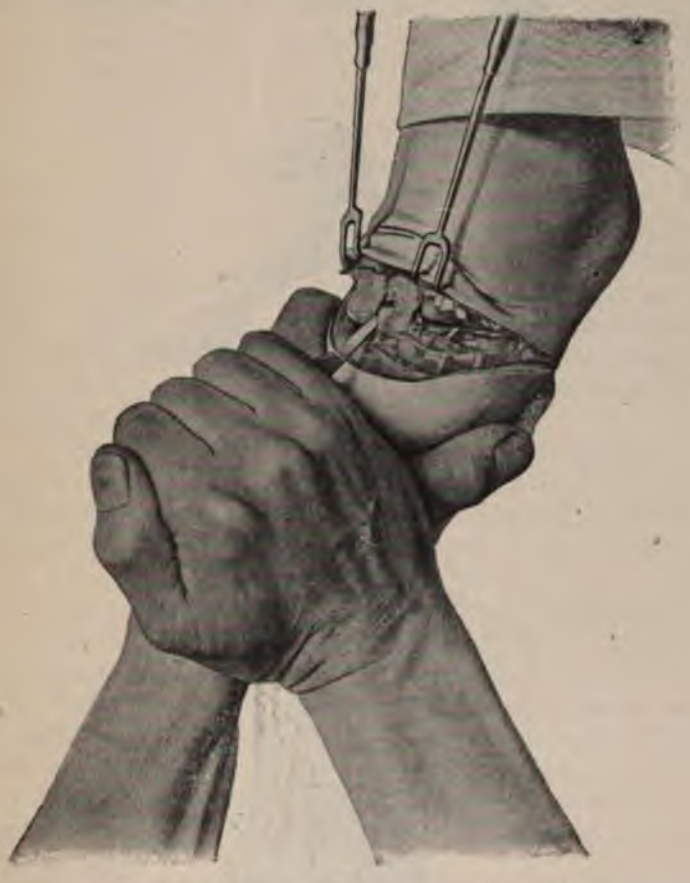


FIG. 1447.—Lisfranc's amputation. (*Burghard.*)

base of the second metatarsal bone with a bone-forceps to avoid the trouble of disarticulating it; or, again, division of all the bones straight across with a saw just below their bases. In amputation for injury the latter method gives excellent results, where the treatment is distinctly aseptic."

Syme's Amputation.—*Step* 1.—Make an incision down to the bone from the tip of the external malleolus to a point ½ inch below the internal malleolus. This incision goes across the sole, but its centre is slightly curved toward the heel (Fig. 1448). Unite the upper ends of this incision by a cut straight across the front of the ankle-joint.

Step 2.—Bend the foot downwards so as to put much tension on the lateral

ligaments of the ankle. Open the joint freely and divide the lateral ligamen
When cutting the soft parts on the inner side of the ankle be careful to cut t
posterior tibial artery low down because of its importance in nourishing the fla

FIG. 1448.—Syme's amputation. (*Farabeuf.*)

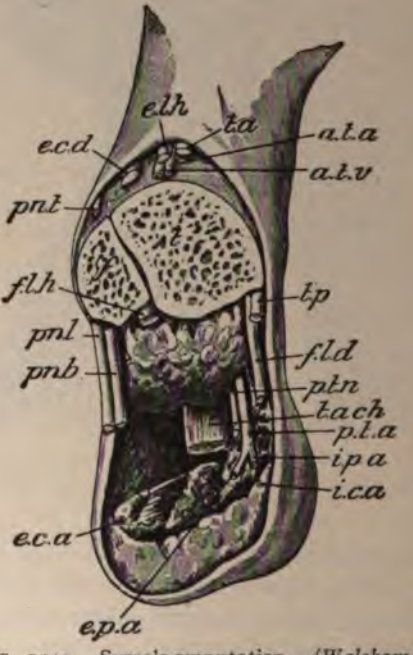


FIG. 1449.—Syme's amputation. (*Walsham.*)

f, Fibula; *t*, tibia; *t.a*, tibialis anticus; *e.l.h*, ext. long. hallucis; *a.t.a*, ant. tib. art.; *a.t.v*, ant. tib. vein; *e* ext. com. dig.; *p.n.l.*, peroneus ongus; *p.n.b.*, peroneus brevis; *f.l.h.* flex. long. hallucis; *t. ach*, t. achillis; tib. post; *f.l.d.*, flex. long. dig; *p.t.a.* post. tib. art., dividing into *e.p.a.* and *i.p.a.*, external and int plantar artery; *e.c.a.* and *i.c.a.*, ext. and int. calcaneal branches forming blood supply of thick heel-fl

Step 3.—By bending the foot more and more, separate the surfaces of ankle-joint and expose the tendo Achillis. Divide the tendo Achillis cl to the os calcis. Dissect the heel flap from the os calcis from above downwar

leaving the flap as thick as possible and *not* punctured. In children the epiphysis may come away with the heel flap and if healthy can be utilized. Remove the foot (Fig. 1449).

Step 4.—With the saw remove both malleoli and with them a very thin slice of tibia. As an alternative remove the malleoli alone (Macleod).

Step 5.—Trim away any excess of tendons or other tissue. Attend to hemostasis. Close the wound.

Watson's Amputation ("Brit. Journ. Surg.," ii, 390.—*Step* 1.—With a knife mark the skin at the following points: (*a*) ½ inch below and behind the tip of the internal malleolus; (*b*) ¼ inch below the tip of the external malleolus; (*c*) 1½ inches distal to the midpoint of a line joining the malleoli anteriorly. Join these points by a curving incision and reflect upwards the flap as far as the ankle-joint. Divide the extensor tendons and anterior tibial vessels. Divide and cut short the anterior tibial and musculo-cutaneous nerves. Open the ankle-joint and forcibly put the foot in the equinus position. Cutting close to the bone divide the internal lateral ligament and the anterior and middle fasciculi of the external lateral ligament. Pass the knife between the astragalus and os calcis and divide the interosseous ligament. Open the astragalo-scaphoid joint and free the head of the astragalus. With strong forceps twist the astragalus from the posterior ligament of the ankle and from the posterior fasciculus of the external lateral ligament.

Step 2.—With a broad gouge or chisel remove the cartilage from the lower ends of the tibia and fibula and from the upper surface of the os calcis. Cut away the sustentaculum tali. Remove the soft structures from the sinus pedi. Subcutaneously divide the tendo Achillis and any contracted fibrous tissue around it.

Step 3.—From the ends of the primary dorsal incision make a cut which reaches to half an inch in front of the tubercle of the scaphoid on the inner side and the same distance in front of the base of the fifth metatarsal bone on the outer side; the cut curves across the sole between these two points. Disarticulate the os calcis from the cuboid and complete the separation of the foot by cutting from behind forwards obliquely, through the soft parts of the sole to the margin of the skin flap, keep the knife as close to the bone as possible. Remove the anterior articular surface of the os calcis. Attend to hemostasis. Cut the nerves short.

Step 4.—Wedge the os calcis between the malleoli and nail it there by means of a 6-inch steel pin driven through the centre of the heel, through the os calcis and into the centre of the tibial shaft. Leave the end of the pin projecting through the skin. If any tension remains about the tendo Achillis relieve it by subcutaneous section but do not injure the posterior tibial vessels. Suture the flaps. Insert a small drain. After two days remove the drain. After 2 weeks remove the pin. Immobilize for about 6 weeks to permit of bony union. The advantages claimed for Watson's amputation are: The original heel pad covers the stump. The retained malleoli give a firm hold to the uppers of ordinary high shoes. There is only about one inch shortening of the limb. No artificial limb is required; an ordinary high shoe can be worn if the sole is stiffened with metal and a block is used to fill the toe space.

Roux's Operation.—This is identical with Symes's except that the flap is *not* made over the heel but on the inner side (Fig. 1450).

Corlette's Amputation. No. 1.—*Step* 1.—From a point midway between the tip of the external malleolus and the tuberosity of the fifth metatarsal make a curved incision over the dorsum of the foot, crossing the bases of the metatarsal bones and ending a little behind the prominence of the navicular bone internally. Make a similar plantar flap a little longer than the dorsal. Modifications of the above incisions must be used in accordance with the tissues available. Make the flaps too large rather than too small. It is easy to trim down large flaps.

FIG. 1450.—Roux's amputation. (*Stimson.*)

Step 2.—Disarticulate at the medio-tarsal joint, as in Chopart's operation. Rowlands and Turner describe the disarticulation as follows: "the anterior half of the foot being strongly depressed, disarticulation is effected by passing the knife above the tubercle of the scaphoid between this bone and the astragalus, and then between the concavo-convex surface of the calcaneo-cuboid joint. In effecting this the position of the joints and the shape of the astragalus must be remembered, and Mr. Skey's words borne in mind: 'the joints should be opened with tact and not by force: if the knife be applied to the right surface, it will pass without effort into the articulation; if in the wrong direction, no force will effect it.'"

Step 3.—With an osteotome cut a horizontal groove round the head of the talus at the junction of the upper two-thirds with the lower third of its convex articular surface, Fig. 1451. Cut away the lower third of the head. Preliminary grooving leads to accuracy and prevents fragmentation of the part to be retained. By shaving the under surface of the upper part of the head, make the plane of the bone slant a little upwards and backwards.

Step 4.—Cut away the sustentaculum tali flush with the side of the calcaneus.

Step 5.—At the junction of the upper third and lower two-thirds of the facet on the front of the greater process of the calcaneus which articulated with the cuboid cut a horizontal sulcus and through this cut upwards and backwards towards the groove in which is inserted the interosseous ligament. The sharp up-curving projection of the anterior end of the calcaneus is now removed.

Step 6.—Cut away the interosseous ligament. With lion forceps pull the calcaneus away from the talus. Cut the lateral, medial and posterior talo-

calcaneal ligaments. Separate the soft tissues from the top and sides of the calcaneus. Cut the long flexor tendons of the toes and that of the hallux as far back as convenient.

Step 7.—Complete the removal of the lower part of the talus making the plane of the cut surface of bone slope upwards and backwards. Do *not* injure the posterior tibio-tarsal ligament and do *not* enter the ankle joint. It is best to remove the bone by "shaving" and not in one piece.

Step 8.—*Shave* off bit by bit the convex articular prominence of the calcaneus until a large plane surface is produced with a moderate slant up from before backwards, Fig. 1451 *a–b*.

Step 9.—Push the calcaneus well forward so that its anterior end projects a little in front of the talus and the two raw surfaces of these bones are in good apposition. To obtain accurate apposition it may be necessary to shave away some more bone. If the projection of the anterior end of the calcaneus is sufficient to threaten injury to the skin flaps, it may be shortened.

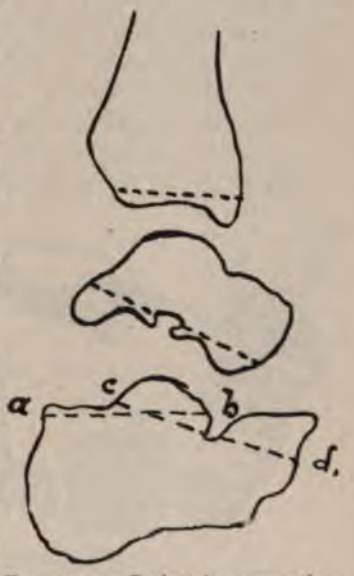


FIG. 1451.—Corlette's amputation.

Step 10.—Drill a hole from side to side through the neck of the talus fairly high up. Make a similar hole through the calcaneus. Put a guide of wire in each hole.

Step 11.—Trim and place in position the skin flaps. Remove the tourniquet and attend to hemostasis.

Step 12.—Unite the talus and calcaneus by means of stiff (2 mm.) silver wire passed through the holes already bored.

Step 13.—Suture the anterior tendons to the plantar flap as low as possible. Close the wound.

Remarks.—One of the great disadvantages of such amputations as Chopart's is that the heel is liable to be pulled up by the Gastrocnemius thus giving a poor stump. Corlette seems to have reason in claiming that the pushing forward of the Calcaneus (Step 9) overcomes this fault by shortening the heel levers. The careful suturing of the dorsal tendons to the plantar tissues (advised by Selegarde in Chopart's operation) aids in securing a good stump.

Corlette's Amputation No. 2.—Step 1.—Reflect flaps as in Corlette's Amputation No. 1, but make them shorter.

Step 2.—Remove the foot by medio-tarsal disarticulation. Remove the sustentaculum tali. Excise the talus.

Step 3.—Separate the soft parts from the sides and upper surface of the calcaneus. Posteriorly this separation need not extend far down the sides of the bone. In making these separations always hug the bone with the rugine or knife lest vessels be injured. Remove the prominent upper and anterior part of the greater process of the Calcaneus.

Step 4.—After grooving the bone slice away the upper part of the calcaneus (Fig. 1451 *c–d*) leaving a plane of raw surface sloping upwards and backwards. This must be done in such fashion that the normal bearing surface of the sole of the heel will be capable of pressing on the ground directly under (in the bearing line of) the tibia after the calcaneus is pushed forward. It is wise to remove the upper part of the calcaneus not *en masse*, but by shaving but by bit. Note that the upper surface of the calcaneus is removed to its posterior extremity, but the line of section does not involve the insertion of the tendo Achillis.

Step 5.—With osteotome remove the articular surface of the tibia between the malleoli, but do *not* injure the compact layer of bone on the articular surfaces of both malleoli; this is important as the malleoli are retained principally to give lateral support and for purposes of wiring.

Step 6.—Fit the cut surface of the calcaneus to that of the tibia. To do this it may be necessary to cut away part of the external malleolus, until it does not project downwards more than the internal. Drill both malleoli near their bases horizontally or slightly upwards and inwards. Drill the calcaneus from side to side. Pass a wire through the holes bored in the malleoli and calcaneus and thus fasten the calcaneus securely to the tibia.

Step 7.—Cut away any excess of calcaneus protruding forwards.

Step 8.—Trim the flaps and close the wound.

FIG. 1452. FIG. 1453. FIG. 1454.

FIGS. 1452 AND 1453.—Pirogoff's amputation. (*Esmarch and Kowalzig.*)

FIG. 1454.—Le Fort's amputation. (*Esmarch and Kowalzig.*)

Pirogoff's Amputation.—*Steps* 1 and 2 as in Syme's amputation.

Step 3.—Make strong plantar flexion until the astragalus is dislocated forwards and the upper surface of the posterior part of the os calcis comes into view. With the saw divide the os calcis vertically immediately behind its articular surface (Figs. 1452 and 1453).

Step 4.—Remove the malleoli and a thin slice of the tibia as in Syme's operation.

Step 5.—Divide the tendo Achillis at its insertion.

Step 6.—Complete the operation as in Syme's.

The sawn surface of the posterior end of the os calcis unites to the tibia, giving a good stump.

Pirogoff's operation is very difficult to perform, and accidents in healing may lead to distortion of the stump.

Le Fort's Operation, a modification of Pirogoff's is sufficiently explained by figure 1454. The incision crossing the sole lies at the posterior margin of the navicular bone.

Amputation of the Leg.—The paragraphs devoted to amputating in general describe sufficiently the usual methods of removing the leg.

It may be remarked that the ventral decubitus presents some marked advantage over the usual dorsal position in amputations below the knee in that flexion of the knee permits the easiest possible access to the territory of operation (Finochietto, "Annals Surg.," May, 1915).

Osteoplastic Amputations.—Osteoplastic amputations are less serviceable after trauma than after disease.

Bier's Osteoplastic Amputation Leg.—Bier's operation may be carried out either on the basis of a circular or a flap amputation. The circular method will be here described.

FIG. 1455.

Step 1.—Make the usual circular incision through the skin and subcutaneous tissue, being specially careful *not* to injure the periosteum. Reflect a cuff of skin upwards (Fig. 1455).

Step 2.—With a knife trace out a periosteal flap with its pedicle above, on the free surface of the tibia. With a fine saw or chisel (the chisel is liable to splinter the bone) separate a shell of bone from the tibia so that a flap is formed consisting of periosteum and bone. The shell of bone ought to be long enough to cover the cut surface of the tibia and the fibula (Bier's method) after the limb is

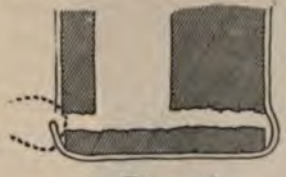


FIG. 1456.

FIGS. 1455 AND 1456.—Bier's osteoplastic amputation.

amputated, or to cover the cut surface of the tibia alone (Kocher). When sufficient bone has been cut away or shaved off the tibia continue the separation of the periosteal flap from the tibia upwards to the line where the bone must be divided (Fig. 1455). Complete the amputation.

Step 3.—Turn the periosteal-bone flap so as to cover the sawn ends of the tibia and fibula or of the tibia alone with the shell of bone (Fig. 1456). Fix it in position with a few sutures.

Step 4.—Attend to hemostasis. Close the wound.

This operation gives a very excellent stump.

Bier's method may be modified in various ways, one of the principal modifications being to construct a flap of skin, periosteum and a shell of bone instead of periosteum and bone alone.

Figures 1457, 1458, 1459, 1460, from Trzebicky and Frommer's article

("Archiv für klin. Chir.," lxx, 472), illustrate this method admirably. No Fig. 1460 that a segment of bone is removed at the base of the bone flap; is, of course, to permit the folding over of the flap. Figure 1461 shows application of the same principle in amputation of the thigh.

Haffter's Osteoplastic Amputation of the Leg.—Dumont describes operation ("Deutsche Zeitschrift für Chir.," xcii, 497).

FIG. 1457.

FIG. 1458.

FIGS. 1457 AND 1458.—Osteoplastic amputation. (*Trzebicky and Frommer.*)

FIG. 1459.

FIG. 1460.

FIGS. 1459 AND 1460.—Osteoplastic amputation. (*Trzebicky and Frommer.*)

Step 1.—Make an obliquely oval incision through the skin. On the side of the limb the incision is at a much lower level than on the *inner* side.

Step 2.—On the inner side retract the skin upwards in the usual manner cut through the periosteum of the tibia (Fig. 1462, a). Push the periost upwards for about ½ inch. Divide the tibia with a Gigli saw (Fig. 1462,

Separate the soft parts from the tibia downwards. Expose the fi near the outer level of the oval skin incision. Divide the fibular periost

g. 1462, b) and push it upwards so as to form a cuff. Divide the fibula g. 1462, B).

Step 3.—Choose a point on the fibula near the level of the sawed surface of

FIG. 1461.—Osteoplastic amputation. (*Trzebicky and Frommer.*)

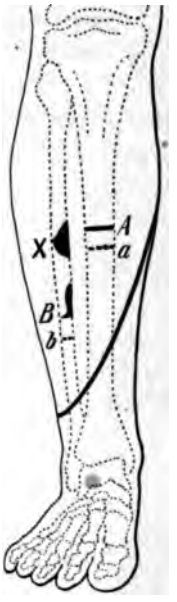


FIG. 1462.—Hafter's osteoplastic amputation.

tibia. At this point cut, with a chisel, a wedge out of the fibula, the base he wedge being directed towards the tibia (Fig. 1462, X).

Step 4.—Bend or break the fibula so that it may be laid over the sawn sur- of the tibia. Vivify the surface of the fibula osed to the tibia. Attend to hemostasis. se the wound with deep and superficial ures in such a manner that the mobilized tion of fibula is left in contact with the end he tibia. Excellent results have been ob- ied by this operation which seems simple sensible.

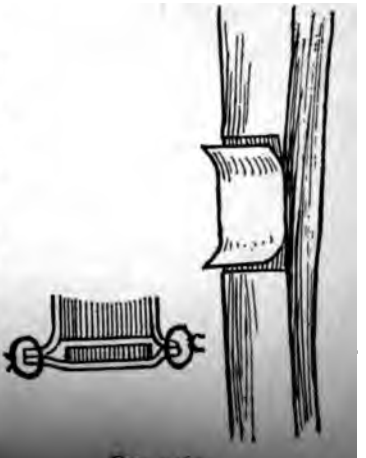


FIG. 1463.

Author's Amputation.—In performing Bier's oplastic amputation the author has been ck by its difficulty and by the ease with ch the plate of bone falls off the periosteal at the last moment. Little or no nourish- it can reach the bone fragment through the osteum which really acts merely as a hinge; herefore operates as follows:

1. Reflect the soft parts by the circular or method but leave the perio

2. Transversely divide the

from each other by a space about ½ inch greater than the bone (Fig. 1463).

From the upper incision separate the periosteum downwa inch. From the lower incision separate the periosteum upw inch. With a saw cut through the compact bone transvers of the periosteal flaps. With an osteotome cut free the plate the two saw cuts. This plate of bone is covered by perioste over its upper and lower edges like a table cloth. Preser bone in warm salt solution or in gauze moistened with salt sc

3. Choose the line of bone section and after forming peri the bone. Attend to hemostasis.

4. Place the plate of bone over the cut surface of the til surface to raw surface) and suture the periosteum of the plate t of the tibia.

5. Close the wound *secundum artem*.

In amputation of the thigh Hayden suggests using the patel off its articular surface, as a free transplant to cover the divided

FIG. 1464.
(*Esmarch and Kowalzig.*)

FIG. 1465.
(*Farabeuf.*)

FIGS. 1464, 1465 AND 1466.—Disarticulation of knee.

Disarticulation at the Knee.—The ordinary methods o of the knee require no special description. They are performe (Fig. 1464), oval (Fig. 1465), or flap (Fig. 1466) methods. or may not be removed.

AMPUTATION BESIDE THE KNEE

Method A.—Carden's Intra-condyloid Amputation.—T incision shown in Figs. 1467 and 1468. Reflect the anterior sk in front of the patella and expose the upper edge of that bo quadriceps extensor at its insertion. Divide the ham-strings a

the popliteal space. Clear the femur immediately above the articular rtilage and divide the femur at this level in such a manner as to give a horizonl surface for the patient to rest on. It must be noted, however, that the soft urts posterior to the knee contract after section, while those anterior do not

FIG. 1467.—Carden's amputation. (*Moullin.*)

lo so, hence a circular flap becomes an oval one on account of the posterior ontraction.

Method B.—Gritti's Osteoplastic Operation.—Make the same skin incision s in Method A, *but* turn up the patella in the anterior flap. Saw off the articu-

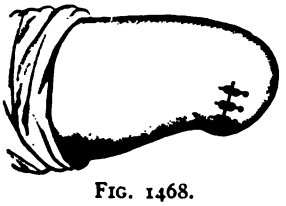


FIG. 1468.

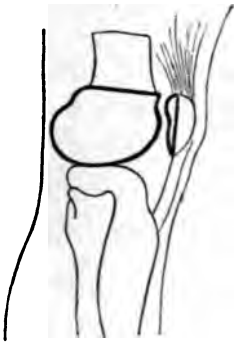


FIG. 1469.

FIG. 1470

FIG. 1468.—Carden's amputation. (*Moullin.*)

FIGS. 1469 AND 1470.—Gritti's osteoplastic amputation. (*Stewart.*)

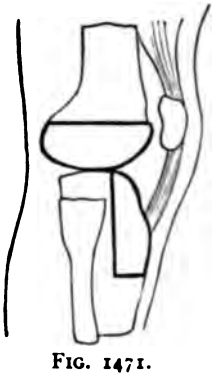


FIG. 1471.

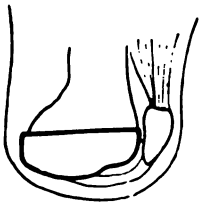


FIG. 1472.

FIGS. 1471 AND 1472.—Sabanejeff's osteoplastic amputation. (*Stewart.*)

ar surface of the patella (Figs. 1469 and 1470). Complete the amputation. Place the sawn surface of the patella (in the anterior flap) against the cut urface of the femur. Close the wound.

Method C.—Sabanejeff's Method.—Make an anterior flap si Carden's but having its lowest point below the patellar tubercle. W or chisel cut off, in one piece with the skin flap, a portion of the anterior surface of the tibia (Figs. 1471 and 1472). Complete the amputation. ing the wound place the bone in the anterior flap in contact with the end of the femur. Both Gritti's and Sabenejeff's methods are valuabl

Amputations of the thigh do not require special description.

AMPUTATION OR DISARTICULATION AT THE HIP

Method of Temporary Hemostasis.—1. Preliminary ligation of iliac artery.

2. Compression of common iliac artery through an abdominal (McBurney, "Annals Surg.," 1894, ii, 181).

3. Preliminary ligation of femoral vessels (a) through a special (b) at an early stage in the "anterior racquet" operation.

4. (a) Trendelenburg's pin.
   (b) Varick's modification of Trendelenburg's pin.
   (c) Thomas' forceps.
   (d) Wyeth's pins.
5. Jordan-Lloyd's tourniquet.
6. Digital compression.
7. Macewen's method of aortic compression.
8. Momburg's method.
9. Senn's method.

Trendelenburg's Pin.—The pin or rod is of steel, 15 to 16 inches l inch wide and $\frac{1}{12}$ inch thick in the centre. The original pin was p with a removable lance-shaped point 2 inches in length. Wyeth's pin answer the purpose. Introduce the pin 1½ inches below the anterior s iliac spine, make it pass in front of and touching the femur to emerge at t terior scroto-femoral junction. Remove the point or protect it with Aided by the pin it is easy to apply a rubber tube in the figure-8 fashio to compress all the soft structures in front of the hip, between the pin a rubber tube. Trendelenburg operated by transfixing about ½ inch be pin, cutting a long anterior flap, ligating the vessels, removing the pi articulating the joint, and, lastly, making the posterior flap.

Varick ("Bryant's Op. Surg.") did not disarticulate until he had tra a second time behind the neck of the femur.

Thomas' Forceps.—Lynn Thomas has devised a long forceps, ve a gastrectomy clamp, one blade of which is passed through the tissues t like Trendelenburg's pin; the other blade pressing on the tissues ou takes the place of the rubber tube. This forceps did yeoman servic Boer war and is a thoroughly practical device (Fig. 1473).

Wyeth's Pins.—Provide two mattress pins each one foot long inch thick. The point should be bayonet-shaped. T below, and slightly internal to, the anterior superi

at superficially through the tissues at the outer side of the hip to emerge on a el with the point of entrance. Insert the other pin through the adductor gus ½ inch below the perineum, to emerge 1 inch below the ischial tuber-

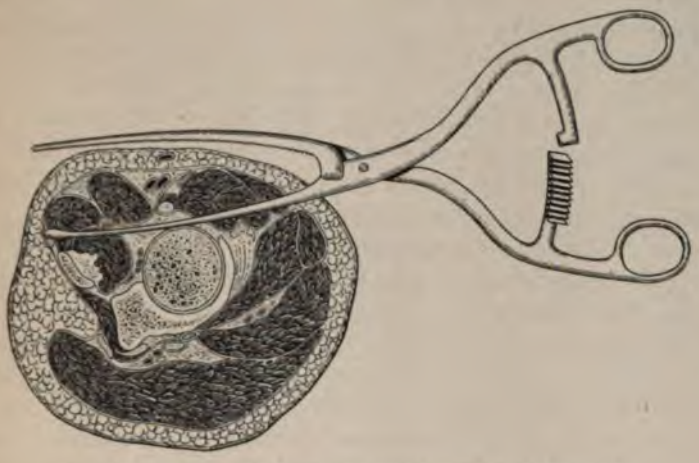


FIG. 1473.—Lynn Thomas' forceps-tourniquet. (*Thomas.*)

ity (Fig. 1474). Protect the points of the pins with corks. Apply a rubber be tightly around the limb above the pins. The pins prevent the rubber tube

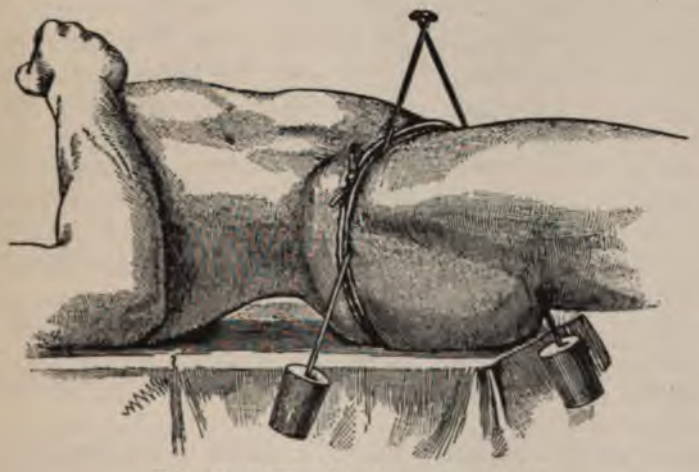


FIG. 1474.—Wyeth's pins. (*Jacobson.*)

m slipping even after the joint is disarticulated and the limb removed. e author has found this method very satisfactory.

Jordan Lloyd's Tourniquet or Elastic Constrictor.—Double a two-yard ce of stout rubber bandage. Pass it between the thighs so that its middle

lies between the ischial tuberosity of the side to be operated on and the anus. Lay a common roller bandage (size for the thigh) lengthwise over the external iliac artery. Pull the ends of the rubber bandage upwards and outwards, one in front and one behind, to a point above the centre of the iliac crest of the same side. There must be no pulsation in the femoral and tibial arteries when the band is in position. The front part of the rubber band runs parallel to and just above Poupart's ligament and, by means of the roller bandage, compresses the external iliac artery. The posterior part of the rubber band crosses the great sacro-sciatic notch and controls the branches of the internal iliac. The ends of the bandage may be held by an assistant or secured as a figure 8 round the body. This method has not the safety of those of Wyeth or Thomas.

Digital compression of the femoral artery is unsatisfactory.

Macewen's Method.—Compression of the Aorta.—Arrange the patient exactly as he is to lie during the operation. Place a platform or steady stool by the left side of the table of such height that an assistant standing on it can lean over sidewise and with his right elbow fully extended lay his closed fist on the aorta immediately to the left of the umbilicus. The assistant placed as above, facing the patient's feet, stands on his left foot, his right foot crossing the left, leans on his right fist and so compresses the aorta with the minimum of fatigue. The writer can vouch for the simplicity and efficiency of the method; he can also vouch for the fatigue of the assistant at the close of the operation.

Momburg's method of controlling the circulation in the lower half of the body ("Zentralblatt für Chir.," 1908, No. 23) is applicable not merely to operations about the hip-joint, but to interilio-abdominal amputations as well. Apply a rubber tube (as thick as a man's finger), under full tension, two to four times around the waist of the patient between the iliac crest and the lowest ribs. Watch the femoral pulse; as soon as it is no longer palpable, enough constriction has been applied. As soon as the operation is completed, apply an elastic bandage to both limbs from the feet up, if the operation has been on the pelvis, or to the remaining limb if one has been amputated. Elevate the limb. Remove the constrictor from around the waist. Gradually remove the elastic bandage from the limb so as to permit the circulation to be resumed by degrees in the lower part of the body lest too great a strain be suddenly put on the heart. Bier, Axhausen, and others have used Momburg's method with success and satisfaction.

The methods of performing amputation or disarticulation at the hip-joint are innumerable, only a few will be described here.

1. **External Racquet Incision.**—This operation and its modifications are practically identical with

Furneaux Jordan's Method.—Place the patient on his back with the buttocks resting on the extreme end of the table. Let the assistant hold the leg and manipulate the limb according to instructions. If desired, provide for temporary hemostasis. Slightly adduct, flex and rotate the thigh inwards.

Step 1.—Make a longitudinal incision from a point about 2 inches above to a point about 6 inches below the tip of the trochanter major. This incision runs along the femur near the posterior edge of the trochanter and penetrates at once to the bone (Fig. 1475).

› 2.—With a stout knife divide the muscular attachments of the tro-
r major and expose the joint. Before dividing the muscular attachments
be well, in certain cases, to expose, open, and explore the joint so that the
tive of resection may be adopted instead of amputation, under proper
stances.

h periosteal elevator, stout knife or scissors separate the soft parts from
ıur (most difficult at the trochanter minor and the linea aspera) for the
gth of the longitudinal wound.

› 3.—**Method A.—Senn's Method.**—Dislocate the head of the femur
ıke it protrude through the wound. Introduce a closed forceps through
und and force it through the tissues on the inner side
thigh so as to make a prominence on the skin. Di-
e skin over the point of the forceps and grasp in its
the middle of a length of rubber tubing. Pull the
through the wound and divide the tube where it
asped by the forceps, thus leaving two portions of
tubing passing completely through the thigh. Tie
these tubes tightly around the anterior, the other
the posterior mass of tissues. This leaves hemor-
luring the completion of the amputation.

Fig. 14.—Senn's operation. Second

thod B.—Dislocate the head of the femur and make
rude through the wound. Pass one blade of a
s's clamp a distance; clamp will fit through the
and make it perforate the skin on the inner side of
gh. Let the other blade of the clamp pass over the
the thigh. Tighten the clamp. This leaves hemor-
a the anterior flap where the principal vessels lie. If desired, a similar
may be applied to the posterior side of the thigh if the soft parts of
erior side may be divided, the vessels secured and then the same forceps
to the posterior tissues, which may be divided in turn. This method of
ceps Thomas uses very generally.

hod C.—[illegible]

4.—[illegible]

ıit.—[illegible]

[illegible]

Reflect the skin upwards to the level of the lesser trochanter. At divide the muscles circularly to the bone.

Step 2.—Make a vertical incision over the line of the external surf femur from the elastic constrictor to the circular incision. Ligate all cipal vessels in the wound.

Step 3.—Separate all the soft parts from the femur upwards from th incision. Disarticulate the hip. To accomplish disarticulation divid sular ligament, make a notch in the cotyloid ligament to permit air to joint, manipulate the limb to expose the ligamentum teres, divide this

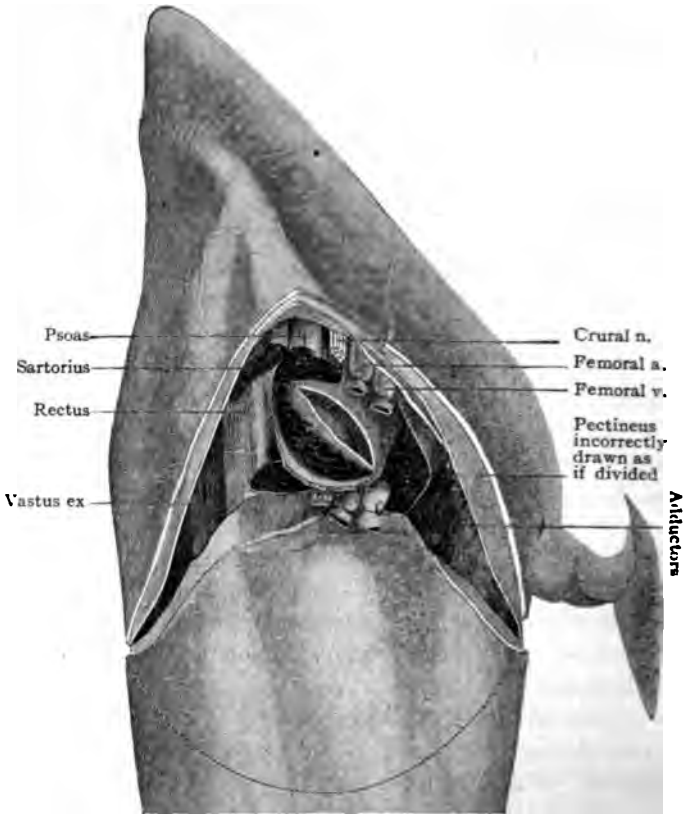


FIG. 1476.—Kocher's amputation. (*Kocher.*)

complete the dislocation by manipulation, using the limb as a lever. S geons divide the femur as soon as they make the circular division of cles; the loss of the limb as a lever makes disarticulation of the joint m difficult.

Step 4.—Remove the limb. If any vessels are visible, ligate the move the elastic constrictor or pins. Attend to hemostasis. Pro drainage. Close the wound. Apply dressings. Wyeth's operation ha great satisfaction to all who have used it. It is very easy and safe

3. **Anterior Racquet Incision.**—This method is convenient be very beginning of the operation the femoral vessels are tapped

divided. The incision encircling the limb in an oblique fashion may
nged as to form two practically equal flaps, one long external flap, one
nal flap, two unequal lateral flaps or one long posterior flap. This
f choice in obtaining material to cover the stump is of importance, as
disease and skin involvement may render it necessary to remove much
oft structures. The anterior racquet method is entirely analogous to
al of a tumor from the body, in this case the limb being considered

.—From a point immediately below the centre of Poupart's ligament
ertical incision downwards for 3 to 4 inches. *Expose, doubly ligate,*
e the common femoral artery and vein. *Divide the crural nerve*
).
.—At the lower end of the vertical incision make an *obliquely circular*
nd the limb, dividing the skin and subcutaneous tissues. *Reflect the*
rd for about 2 inches, and divide the muscles at this level. *Any vessels*
bturator, superior, and inferior gluteals) must be caught in hemostats.
—Separate from the bone any *soft structures still attached, and*
e limb by disarticulation.
—Attend to hemostasis. *Provide for drainage. Close the wound.*

eration as above described is suitable in many cases, but the removal
lisarticulation of the hip for sarcoma of the femur cannot be considered
lder term than vile. This is due to the fact that the sarcoma early
e soft parts—for instance, the muscles—and it must primarily be
Quénu et Desmarest, "Rev. de Chir.," 1897, No. 5). Given a
ll in fair vitality, one should therefore usually try to remove the sarcoma
ribed so as to expose and divide the muscles at their pelvic origin.
ther suggest the following method of disarticulation of the hip as being
relatively suitable in sarcoma of the femur.
—Through a muscle-splitting incision expose the common iliac artery
extremity. Apply to the vessel Cole's clamp, or a temporary
Pack and protect the wound if necessary using a sheet or a towel
scissors to temporarily close the wound. Instead of the above method,
a clamp mentioned may be employed (p. 1184).
—Make a vertical incision over Poupart's ligament, expose, doubly
divide the femoral vessels. Divide the anterior crural nerve.
—Beginning at the lower end of the vertical incision, cut out an
of skin and subcutaneous tissues sufficient to cover the wound which
by the operation. These flaps of skin and subcutaneous tissues must
ll up to the crest of the ilium. The rami of the pubis and ischium, the
ernity, etc., etc., so that the muscles connecting the femur and the
completely exposed, except of course those coming from inside the
—Separate the muscles from the pelvis at as very near their origin
t free downwards until the hip-joint is exposed all around. Divide
g to the femur from inside the pelvis, these cannot be reached
—Disarticulate. Remove the limb.

Step 6.—The femoral vessels have already been ligated. Look out for and ligate the gluteal and sciatic vessels (Fig. 1477). Pick up and ligate all visible vessels. Pack the huge wound with gauze wrung out of very hot water.

Step 7.—Reopen the abdominal wound. Let a competent assistant remove the Crile's clamp and hold himself ready to compress the iliac if necessary. Review the amputation wound. Arrest all hemorrhage. Provide for drainage. Close the wound.

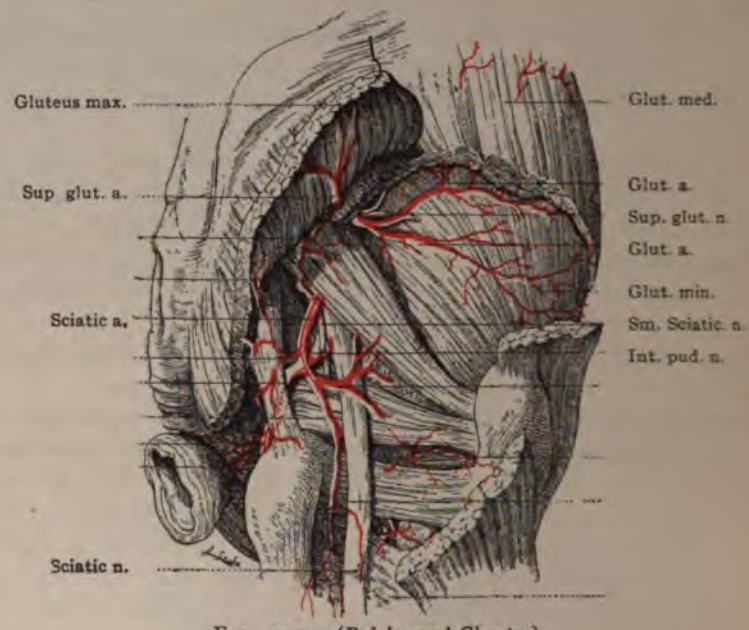


FIG. 1477.—(*Poirier and Charpy.*)

Step 8.—Close the abdominal wound. Apply dressings.

Felix Franke ("Zentralblatt für Chir.," 1897, No. 45, and 1913, No. 3) notes that after disarticulation the acetabulum forms a cavity which may interfere with healing; therefore in suitable cases he advocates amputation through the neck of the femur, leaving the head of the bone to fill the cavity.

Interilio-abdominal Amputation (Jaboulay's Operation).—*Step* 1.—Beginning at the symphysis of the pubis, make an incision parallel to and below Poupart's ligament. Continue the incision the whole length of the crest of the ilium. Expose the peritoneum without opening it and separate it by gauze dissection from the underlying structures until the common iliac vessels are exposed. Doubly ligate and divide the common iliac artery. Do the same to the external iliac vein.

Step 2.—Make a circular incision through the skin and subcutaneous tissues completely round the thigh at the junction of its middle and upper thirds. From a point in the middle line of the anterior surface of the thigh make an incision upwards and inwards reaching from the circular incision to the pubis. From the same point make a similar incision up to the anterior superior spine. These two cuts meeting the cut made in Step 1 surround a triangle of tissue

which must be sacrificed, and outline a very large posterior, cuff-like flap. Reflect the cuff-like flap of skin and subcutaneous tissue so as to expose the whole base of the thigh and its pelvic connections.

Step 3.—Retract the spermatic cord (or round ligament) inwards and upwards. Separate the rectus and pyramidal muscles from the pubis on the affected side. With a stout knife divide the symphysis. Separate the corpus cavernosum and the muscles and fascia from the ischio-pubic rami. Abduct the thigh forcibly so as to make the symphysis gape. Separate from the bone the soft structures arising from the inner surface of the ilium, as the thigh is more and more abducted. If these structures are involved remove them also. Divide the psoas. Expose and divide the sacro-iliac articulation from within outwards. Divide the structures emerging through the sciatic notches. When this is done it is easy to remove the limb and corresponding portion of the pelvis.

Step 4.—After reviewing the wound, cover it by the large cuff-like flap. Various modifications of the above operation have been attempted. At the best it is a most formidable procedure. If the disease is sarcoma, recurrence is almost sure to take place should the patient survive the operative ordeal. When the operation seems indicated for tuberculous disease of the hip involving the ilium, most surgeons would operate in two or more stages, for instance: (*a*) Amputate or disarticulate at the hip-joint. This *per se* might so increase the resisting power of the patient by removing a great source of absorption that nature might possibly cure the patient. (*b*) At a later stage the surgeon may remove part or all the ilium as may be indicated.

CHAPTER CVI

FLAT-FOOT

When flat-foot is due to rupture of the deltoid ligament and chronic dislocation of the astragalo-navicular joint Katzenstein's operation may be of value (see p. 1067).

Ogston's Operation.—Apply Esmarch's bandage. On the inner side of the foot make an oblique incision in such a manner that the middle of the cut crosses the astragalo-scaphoid articulation. With a periosteal elevator expose those portions of the head of the astragalus and the scaphoid which are contiguous to the joint. With a chisel remove sufficient of these bones (especially of the astragalus) that when their cut surfaces are approximated the sole of the foot is arched in the normal fashion. Ogston maintains the bones in apposition by means of bone pegs; this is perhaps unnecessary. Close the wound without drainage. Dress. Immobilize with plaster of Paris. Place limb in elevated position. Remove Esmarch's bandage. Treat the case as a fracture.

Gleich's Operation.—Gleich in 1893 described his operation of cuneiform osteotomy of the os calcis. Brenner modified the operation in that he advised a mere oblique section of the bone in place of the removal of a wedge. It is Brenner's modification as performed in von Eiselsberg's clinic that is here described. The results have been very good. Riedl reports that 87 per cent. of Brenner's patients are cured, many of them being able to serve in the army.

Step 1.—Apply an elastic constrictor to the thigh. Place the foot an on a sand-bag in such a manner that the *whole* inner (tibial) side of the fo ankle is imbedded in and steadied by the sand-bag. One finger's b behind the external malleolus make an oblique incision down to and th the periosteum of the os calcis. Brenner prefers to operate on the inn (H. Riedl, "Archiv für Klin. Chir.," xcii, p. 416).

Step 2.—With an osteotome divide the os calcis obliquely from above wards and forwards. It is well to use a broadbladed osteotome in or avoid splintering of the bone and to leave a smooth cut surface. As soon bone is divided cut the periosteum on the inner side of the bone. Co mobility of the posterior fragment of bone is necessary; if it is not mobile undivided strands of periosteum must be looked for and, when found, cu

Step 3.—Push the fragment of bone downwards, forwards and a trifle in to the desired extent. If valgus is a feature, then the lateral dislocation fragment must be more pronounced. The downward displacement shou about ½ to ¾ inch. If the operation has been properly performed the ought to tend to stay in its new position.

FIG. 1478.—Brenner's modification of Gleich's operation. (*v. Eiselsberg.*)

Step 4.—Hold the bone in position. With a knife or tenotome punctu skin of the heel over the end of the os calcis. Introduce a drill through th puncture, and fix the fragment of bone in its new position by means of thi Brenner does not nail the bone.

Step 5.—Close the wound without drainage. Apply dressings. Lea drill *in situ*. Immobilize with plaster of Paris in a position of slight supi and plantar flexion. Remove the elastic constrictor.

After about two weeks remove the drill without taking off all the pla Paris. About three weeks after operation renew the plaster of Paris so th patient can move about without risk to the calcaneum. Bony union is ge complete about six weeks after operation. Figure 1478 shows the resul patient of v. Eiselsberg's two years after operation.

Nicoladoni's Operation.—Paralysis of the gastrocnemius is liable to l *talipes cavus*, the arching of the foot being caused by the unrestrained act the short muscles of the foot. Nicoladoni imagined that if, in severe ca

the short muscles were given free play by throwing their antagonists out of action their action would tend to cure the deformity. If the tendo-Achillis is divided and kept temporarily from reuniting the above conditions will be fulfilled. The following is Nicoladoni's operation with a trivial modification by Hertle:

Step 1.—Perform subcutaneous tenotomy of the tendo-Achillis at the classical site.

Step 2.—At a point about 1½ inches higher than the puncture of the tenotome, make a longitudinal incision about 2 inches long along the inner side of the tendon. Separate the tendon from its surroundings and pull its stump out of the wound.

Step 3.—Fold the mobilized tendon upwards and tuck its cut end under the deep fascia of the leg. Fix the cut end of the tendon in position by one or more sutures.

Step 4.—Close the skin wound. Dress. Immobilize for ten days. After about ten days remove all immobilizing apparatus and encourage the patient to walk. The more exercise is taken the more likely are the muscles concerned to cure the deformity.

It was Nicoladoni's intention to repair the tendo-Achillis after the flat-foot was relieved but neither he nor Hertle have found it necessary. Results are reported to be excellent not only are the pains permanently relieved, but an anatomic correction of the deformity is often obtained. The tendo-Achillis reforms after a time.

Ernst Müller's Operation ("Centralblatt f. Chir.," 1903, p. 40).—In flat-foot, especially when muscles are spastic, the tibialis anticus tendon often stands out like a cord and its site is marked on the skin by a pigmented line. The object of Müller's operation is forcibly to correct the position of the foot and to retain the new position by means of the anterior tibial tendon. In thirteen cases the operation gave satisfactory results.

Step 1.—Tenotomy of tendo Achillis to permit elevation of arch of foot.

Step 2.—From a point below and behind the internal malleolus midway between it and the sole, make a curved incision along the margin of the arch of the sole to the base of the first metatarsal bone.

Step 3.—Find and divide the insertion of the tibialis anticus at the anterior end of the wound. Isolate the tendon up to the ankle.

Step 4.—Expose the plantar surface of the navicular bone and bore a hole, the size of a lead-pencil, through it from below upwards and slightly backwards.

Step 5.—Pull the tendon of the tibialis anticus through this bone tunnel by means of a thread.

Step 6.—Push the arch of the foot forcibly upwards. Pull the tendon strongly down and wind it around the inner margin of the navicular bone. Fix the tendon to the bone or periosteum with wire sutures. Close the wound without drainage. Dress. Immobilize in plaster of Paris for four weeks, after which massage and passive movements are begun. The "flat-foot sole" should be used until there is complete functional recovery.

Eugen Müller ("Brun's Beiträge," lxxxv, 424) writing of Ernst Müller's operation says it is only suitable in severe cases, *e.g.*, those in which there is a complete sinking of the arch when weight is borne on the foot. If a flat-foot

plate is used, it causes great pain. When the condition is recent the bones involved still preserve their normal shape or are only slightly deformed and they retain their normal mobility. The normal arch can be restored by manipulation when no weight is borne on it, and when the ankle-joint is in a position of plantar flexion, *i.e.*, when the tendo Achillis is not stretched. If one tries to bring such a foot to a right angle with the leg or to flex it dorsally the flat-foot immediately recurs, the head of the astragalus and the navicular bone becoming prominent in the sole. In such cases the tendo Achillis is short. The tendon shortness hinders the calcaneum, and with it the astragalus, from being brought to a right angle to the leg—if one attempts to attain such a position the motion is not accomplished at the ankle but between the tarsal bones and is combined with pronation, thus giving rise to flattening of the arch and prominence of the head of the astragalus and navicular bone. In some cases a marked looseness of the tarsal joints develops and the achillotomy plus transplantation of the tibialis anticus are insufficient. Weight on the foot causes it to become pronated to such an extent that the inner margin of the sole still touches the floor. In such conditions arthrodesis of Chopart's or the talo-tarsal joint ought to precede tendon transplantation. In a few bad cases pronation may be combatted by shortening of the tibialis posticus. Eugen Müller reports many remarkably good results.

According to Vulpius ("Die Sehnenüberpflanzung"), weakness or paralysis of the tibialis anticus and posticus and of the gastrocnemius is the principal cause of paralytic flat-foot (pes abductus pronatus). The appropriate treatment therefore consists, first, in overcorrecting the existing deformity; and, second, in preventing recurrence by strengthening the affected muscles, and if necessary shortening their tendons. The after-treatment includes exercise of the adductors, supinators, and dorsal flexors; and the use of an articulated support to the sole until sufficient muscular strength is developed. One example of Vulpius' method of treatment will suffice:

K. K., four years. Paralysis in second year. Marked equinus and flat-foot. Tib. ant. and post. completely paralyzed. The other muscles in good condition. Shortening of the Achilles and peroneal tendons. *Operation:* Rectification of deformity. Tenotomy of tendo Achillis. Transplantation of peroneus longus on to tibialis posticus, of the extensor hallucis and a good portion of the ext. digitorum on to the tibialis anticus. *Result:* After two months foot was in good position and all movements possible. After one year adduction and supination could be carried out with power.

CHAPTER CVII

TENDON SHEATHS AND TENORRHAPHY

Operation is most commonly performed on the sheaths of tendons for the removal of tuberculous disease.

Apply a tourniquet above the site of disease. Make an incision over the swelling, following the course of the tendon. Split the sheath of the tendon wide open. Retract the edges of the sheath wound with sharp hooks or volsellae. Dissect away all diseased tissues. If possible, do not touch the wound with the fingers unless gloves are worn. Rub into the whole wound sterile iodoform. Close the wound by sutures. Apply dressings and splint.

Tendon Suture: Tenorrhaphy.—To avoid unnecessary cutting it is well to use a round needle, such as is used in intestinal work, but this is not of much importance. All the ordinary suture materials are used, viz., catgut, silk, hemp,

FIG. 1479.

FIG. 1480.

FIG. 1481.

silkworm-gut, silver wire, kangaroo tendon, etc. If catgut is chosen, it ought to be of the chromicized variety.

The accompanying figures elucidate the various methods of applying sutures better than any number of words (Figs. 1479 to 1488). Note in figure 1483 the

FIG. 1482.

FIG. 1483.

FIG. 1484.

FIG. 1485.

supporting suture, and in figure 1486 the ligatures tied around the ends of the tendon to prevent the sutures tearing out. All the above methods of suturing are applicable where the divided ends of tendon can be brought into direct apposition. Sometimes it is necessary to suture a round to a flat tendon, in which case the flat may be folded over the round and there fixed by a few stitches

(Fig. 1489), or the end of one tendon may be drawn through a split or "button hole" in another tendon and sutured (Figs. 1490, 1491, 1492).

Tendons being composed of parallel bundles of fibres, it is easy for sutures to cut their way out by separating the fibres. Suter ("Arch. f. klin. Chir.," lxxii, 728) describes several easy and efficient means of avoiding this accident. Figures 1493 to 1497, show how the sutures are introduced; the ends of the sutures are tied together at one side of the tendon (Fig. 1498). After

FIG. 1486.

FIG. 1487.

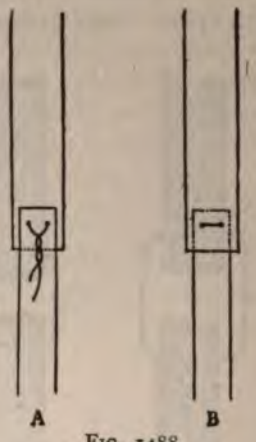


FIG. 1488

FIG. 1489.

the sutures are in place tie the two ends A A^1 to the two ends B B^1 (Fig. 1499); and thus obtain lateral approximation of the ends of the tendon. For further security the two ends of suture A A^1 may be made to surround both segments of tendon, and the same may be done with the suture B B^1 (Fig. 1500). After healing takes place it becomes impossible to distinguish between a union obtained by this method and that by end-to-end approximation. If end-to-end approximation is desired, the sutures A A^1, B B^1, may be used as relaxation sutures. Often it is impossible to bring the ends into the desired apposition, owing to shrinkage, loss of substance, or the exigencies of transplantation, and various

FIG. 1490.

FIG. 1491.

FIG. 1492.

FIG. 1493.

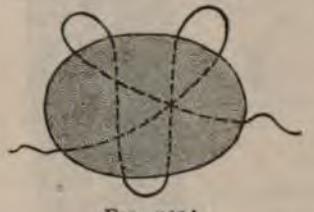


FIG. 1494.

FIG. 1495.

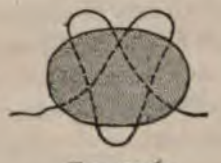


FIG. 1496.

FIG. 1497.

FIG. 1498.

FIG. 1499.

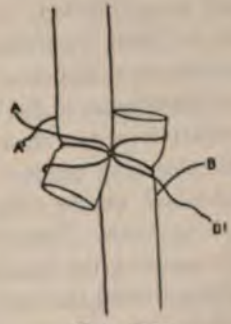


FIG. 1500.

FIG. 1501.

means of tendon lengthening must be used. Figures 1502, 1503, 1504 and 1505 show the best-known methods. Occasionally the above means are inapplicable, and in order to obtain union between the separated ends of tendon it is necessary to fill the gap with some suture material or a graft. Figures 1482 and 1483 show how such sutures may be applied.

Hunkin devised the following useful stitch:

Put the two fore ends of a double silk or hemp suture through the eye of a needle. Introduce the needle into the cut surface of one tendon (X) and make it follow the course shown in Fig. 1506. When the needle at last emerges (Y) tie the ends of the suture Y to the loop X by means of a half-hitch.

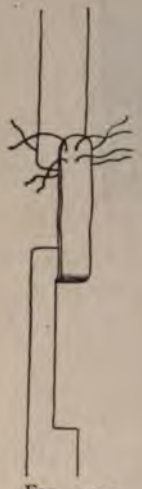


FIG. 1502.

FIG. 1503.

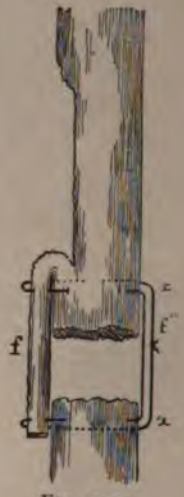


FIG. 1504.

FIG. 1505.

A number of strands of catgut or catgut and silk together may be formed into a small cable the ends of which may be sutured to the divided end of the tendon. Whatever material is used to fill the gap, it merely acts as a guide or scaffold along which nature may deposit new tendon tissue or a substitute therefor. Vulpius finds that even after aseptic healing silk sutures are ultimately thrown off, without ill result, in 15 to 20 per cent. of all cases when used as ordinary tendon sutures. When used as grafts, more damage must follow. Probably as a graft, chromicized catgut or prepared tendon is preferable to silk. A combination of silk and catgut is well recommended. If two neighboring tendons are in part destroyed by the same accident, a portion of the less important one may be used to replace the defect in the more important (Fig. 1507). When, as a result of an incised wound, *e.g.*, of the dorsum of the foot, a tendon is divided, the proximal end is immediately retracted into its sheath. To find the retracted portion pass forceps up the sheath, seize the tendon, and pull it down. Very commonly, this procedure is futile, and we are compelled to split open the sheath for a greater or less distance upwards. The retracted tendon may be forced downwards by methodically pressing the muscular belly downwards or by applying an elastic bandage tightly around the limb from the origin of the muscle at fault downwards. If after thorough and extensive search the upper end of the tendon

cannot be found, the distal end ought to be united to a neighboring tendon by the methods shown in figures 1490, 1491, and 1492. The approximated surfaces of tendon must, of course, be suitably freshened before the sutures are applied.

Sometimes the proximal end of the tendon is accessible and the distal lost or destroyed. Several methods of treatment are applicable: (*a*) The end of the tendon may be united to the side of a neighboring tendon. (See "Transplantation of Tendons.") (*b*) The end of the tendon may be fixed to the peri-

FIG. 1506.

FIG. 1507.

osteum or to the bone itself at a point as near as possible to its normal insertion. (*c*) The end of the tendon may be united to the bone at its normal point of insertion by the intermediation of a catgut or silk graft.

Implantation of tendon to periosteum or bone may be affected as follows:

Method 1 (Lange).—With knife and periosteal elevator raise a flap of periosteum, ½ to ¾ inch in length, at the site chosen for the tendon insertion.

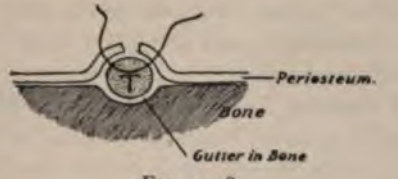


FIG. 1508.

Suture the end of the tendon to the periosteal flap. When the tendon is not long enough to reach the point of insertion, Lange makes use of a double suture of strong silk as a graft.

Method 2 (Wolff).—Divide the periosteum at the site selected. Reflect the periosteum laterally. With a chisel, cut a gutter or groove in the exposed bone. Place the tendon in the bone gutter. Replace the periosteal flaps *over* the implanted tendon and suture them together and to the tendon (Fig. 1508).

When tendon suturing is done as a secondary operation, the ends of the tendon will be found adherent to a mass of scar tissue lying between them, and

which is firmly adherent to surrounding structures, especially to th Before the vivified ends of the tendon are united, this mass of firm, har must be thoroughly excised, and adhesions which prevent approximat gliding of the tendons must be broken down.

Where it seemed impossible to obtain a satisfactory result by excising tissue in a case in which the distal portion of the flexor of the index fin adherent to the cicatrix, Chassaignac sought for, found, and united the p portion of the tendon to the scar close to the distal portion (tendo-cut suture).

After-treatment.—The wound having been closed, if possible w drainage, abundant dressings are applied, and the parts fixed by splints or of Paris in such a position that tension on the sutures is relaxed. No at at motion should be made before the lapse of two weeks, in the case of the s

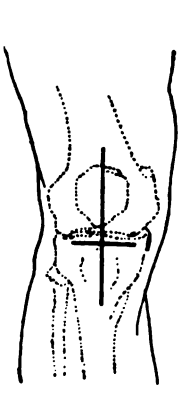


FIG. 1509.

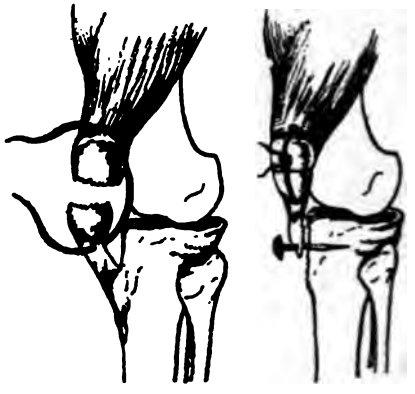


FIG. 1510.

tendons; for the larger tendons, or in cases where grafts (of catgut, silk have been employed, a longer period of rest is proper. After this passi then active motion must be begun, aided by massage and electrical stimu Owing to the occurrence of atrophy from disuse the after-treatment will b prolonged where the tenorrhaphy was secondary than where it was per at the time of the original injury.

Approximation of Severed Ends of Tendon by Means of Transp its Osseous Insertion (Bergmann, Poncet).—It may be impossible, by or means, to approximate the fragments in transverse fracture of the in rupture of the ligamentum patellæ or quadriceps tendon, but the fol operation may suffice to permit it:

Step 1.—Expose the parts by means of a vertical or crucial incision 1509, 1510).

Step 2.—With a chisel separate the tibial tubercle, and with it th mentum patella, from the tibia.

Step 3.—Divide any adhesions which prevent approximation.

Step 4.—Unite the fragments of bone or tendon by strong sutures

Step 5.—The fragments of bone or tendon having been united, the tibial tuberosity attached to the ligamentum patellæ [illegible]

umed a new position on the surface of the tibia. Fix the tibial tuberosity ts new position by means of a buried ivory peg or by a steel nail, which is protruding through the skin wound, to be removed after union has been ured.

Step 6.—Suture the fascia and skin-wounds. Apply dressings. Immobi- with splints or plaster of Paris in extended position and elevate the limb.

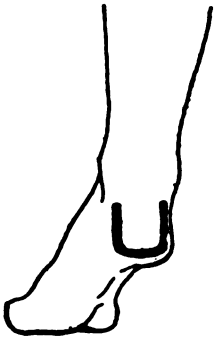


FIG. 1511.

FIG. 1512.

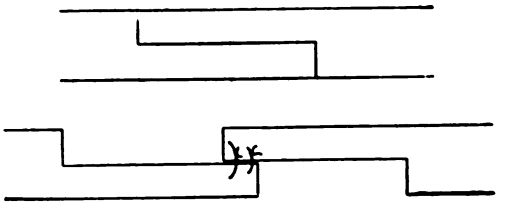


FIG. 1513.

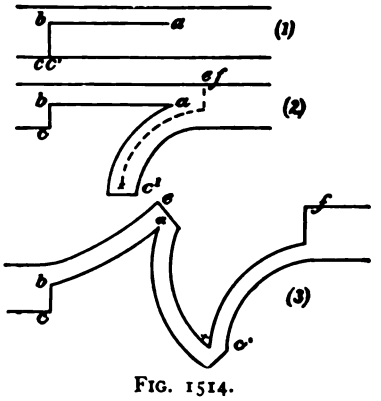


FIG. 1514.

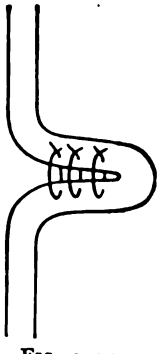


FIG. 1515.

A similar operation may be used in cases where there is much loss of sub- nce in the tendo Achillis or in the tendon of the triceps brachialis. Figures 1 and 1512 are self-explanatory.

For the correction of deformity, tendons which have never been divided :n require to be lengthened. Tenotomy is the most common means of

securing the necessary elongation. (See "Tenotomy.") Poncet's
of making shallow lateral incisions (Fig.) 1505 may be of service und
circumstances. Anderson's method of tendon lengthening by splitting,
and suturing is shown in figure 1513. The Hibbs-Sporon method
readily grasped by glancing at figure 1514.

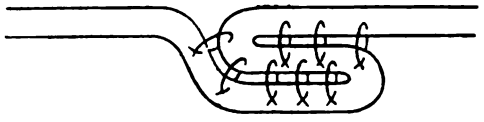


FIG. 1516.

Tendon Shortening.—After the correction of deformity certain t
may be too long for the proper transmission of power, or the exigen
transplantation may require that they be shortened. Figures 1515 an
show a simple reduplication of the tendon. In figure 1517 the tendon
longitudinally and the longitudinal converted into a transverse woun
figure 1518 the whole thickness of the tendon has been cut away wi

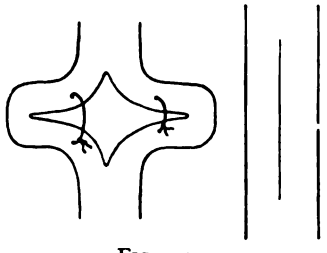


FIG. 1517.

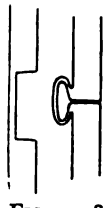


FIG. 1518.

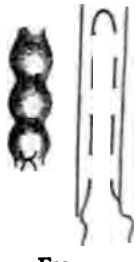


FIG. 1519.

exception of a thin slip at the side, which aids in the subsequent he
In figure 1519 a "draw" stitch when pulled tight throws the tendon into
and so shortens it. Figures 1541, 1542, 1543, 1544, show in detail how
a tendon as the Achilles may be shortened. Other methods of tendon s
ening will be incidentally described in the paragraphs devoted to transplanta

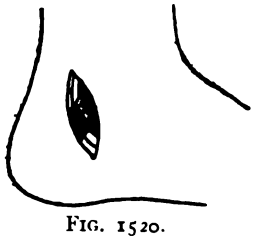


FIG. 1520.

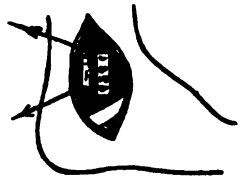


FIG. 1521.

FIGS. 1520 AND 1521.—Operations for displaced peroneus longus tendon.

Displacement of Peroneus Longus Tendon.—Make an incision
2 inches in length, obliquely from above downwards and forwards, ove
outer surface of the external malleolus (Fig. 1520). Do not cut deeper
the subcutaneous tissue. Expose the external annular ligament, whic
torn when the peroneus tendon is luxated. If the fragments of the ligam
can be brought into apposition over the tendon, suture them in their

position. If this cannot be done, expose a larger surface of the external malleolus and from it raise a flap of periosteum with its base downwards. Turn this flap downwards and suture its free extremity to the remnants of the annular ligament or to the periosteum of the os calcis. Another method consists in making the periosteal flap at a slightly higher level—turning it back over the peroneal tendons and there suturing it to the deep fascia (Fig. 1521) (Walsham). Close the skin-wound without drainage. Dress. Immobilize for two weeks and then begin passive motion.

Instead of using the periosteum, Lexer obtains a free (unattached) slip of tendon from the tendo Achillis or the rectus femoris (of the patient himself or from a recently amputated limb) and either sutures it to the periosteum as a bridge over the peroneal tendon or he nails its ends into a gutter cut in the malleolus above and another gutter cut in the os calcis.

TENDON TRANSFERENCE OR TRANSPLANTATION

Objects.—The objects of tendon transference are:

"(*a*) To fortify a weakened group of muscles.

"(*b*) To supplant a completely paralyzed muscle or group of muscles.

"(*c*) To obstruct, balance or oppose an overacting spastic group.

"(*d*) To deviate tendon action when perverted—as in transference of the tendo Achillis to the outer side of the os calcis in congenital club-foot to prevent inversion of the ankle.

"(*e*) As a help in partial arthrodesis" (Robert Jones).

Principles.—H. O. Thomas has pointed out that a muscle may fail to act and may simulate paralysis because it has been overstretched while weak. This is well seen in wrist drop. Here the weakened extensors may have recovered from the original disease, but the stronger flexors have so stretched and dominated them that they no longer act, while the dominant flexors have assumed a condition of contracture from long-continued want of opposition. If such a hand is gradually brought into a position of overextension and kept in that position for many months *continuously*, recovery may be expected. The recovery is due to shortening of the weakened tendons (the muscles of which ought of course to be treated by massage, etc.) and to elongation of the contracted (flexor) tendons (Tubby and Jones).

This recognition of simulated paralysis is of very great importance when one is deciding on operation. Frequently brilliant immediate results have been obtained by tendon transference, but later there has been relapse. This is commonly due to neglect of the Thomas principle referred to in the preceding paragraph. After being transferred or transplanted, a tendon is naturally weak and the point where it is united to its new insertion consists of weak scar tissue. If after the wound has healed we permit undue strain (exerted by gravity or by opposing muscles) to be inflicted on the transferred tendon it cannot avoid being stretched and becoming useless. The transferred tendon ought to be treated on the same principles as recommended in wrist drop, and the treatment should be kept up until "the patient is able by a voluntary effort to make it forcibly act and it can successfully withstand the action of

' flail-joint;" the loss of function is too wide-spread and tl
no neighboring muscles in proper position to lend power.
been loss of tendon from accident or disease, and union, w
implantation, or by tendon lengthening, is impossible, the
may restore function. Frequently paralysis following ac
is circumscribed, so that healthy muscles are found alongsid
in such cases transplantation may be valuable. Before op
we must be very sure that spontaneous recovery is impossibl
until six or nine months have elapsed since the paralysis a
plantation is of use not only in restoring function, but in ob

The most common forms of partial paralysis requiring o
about the ankle evidenced by the presence of talipes ca
varus and equino-varus, and flat-foot. In spastic paralysis tl
lar balance may be due to increased power in one set of mus
out diminished power in the opposing muscles. Inflammat
cause contractures remediable by transplantation.

A well-defined plan of procedure must be worked out in
operation is begun. We must know exactly which musc
completely or partially, and what power is available to aid tl
of adults we study the possible voluntary movements. Move
parts may often be demonstrated only when the correspo
the opposite limb are set in motion. Children we watch at p
certain muscles to act by tickling, etc. When contractures
may hinder certain motions and may have caused atrophy i
from disuse. Electrical tests, according to Vulpius, are
little value. Weak currents do not stimulate sufficiently; sti

the proper tension for the transmission of power. If the operation for the correction of deformity is severe, transplantation should not be attempted until the parts have completely recovered from the operative trauma. If contracted tendons hinder complete correction of deformity, Vulpius defers the necessary tenotomy until he is ready to transplant, when he combines tenotomy and tendon splitting.

Lorenz ("Centralblatt für Chir.," 1905, No. 49) considers that the operation has been overdone, especially in cases of paralytic flexion of the knee. In such cases it is easy to produce hyperextension of the knee (genu recurvatum). For him the biceps, semimembranosus and semitendinosus constitute a "*noli me tangere.*" At most, the gracilis, semitendinosus, sartorius and tensor vaginæ may be used to help the quadriceps, but this amount of help is insufficient.

General Remarks on Method of Operating.—Incisions to expose the tendons should be longitudinal and so placed that they may be slid over all the parts it is necessary to expose. An incision ought *not* to be made directly over a tendon; it should be to one side of it. Flaps and **V**-shaped incisions lead to extensive skin dissection and favor the formation of adhesions.

If the donating tendon is remote from the receiving tendon, a second incision will be necessary, and the tendon is carried from the one opening to

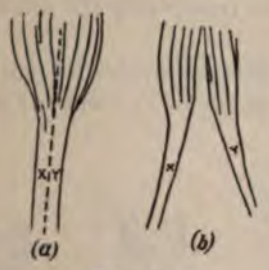


FIG. 1522.

FIG. 1523.

the other through a tunnel bored with a forceps. Numerous incisions may be made into both the donating and the receiving muscle. These incisions let us know the actual condition of the muscles. Next to a dark-red healthy muscle we may find a yellowish-white muscle completely paralyzed and scarcely distinguishable from the surrounding fat. Another muscle may show varying shades of rose color (atrophy from disuse); such a muscle may recover. In still another muscle we may find all three conditions—health, paralysis, atrophy in streaks.

In exposing the donating tendon a very long incision may be required, especially if it seems necessary to form two muscles out of one. Under such circumstances not only is a slip split off the donating tendon, but the tendon split or incision is carried well up into the muscle belly. In continuing the "split" up into the muscle do so by blunt dissection, and see that the portion of muscle left attached to each segment of tendon normally belongs to that

segment. This renders possible the formation of two physiologically distinct muscles out of one (Figs. 1522 and 1523). The donating tendon must be conducted by as straight a route as possible to the receiving one. To succeed in this, *e.g.*, when a flexor of the leg is to donate power to an extensor or *vice versa*, it may be necessary and proper to conduct it through a tunnel bored in the interosseous membrane.

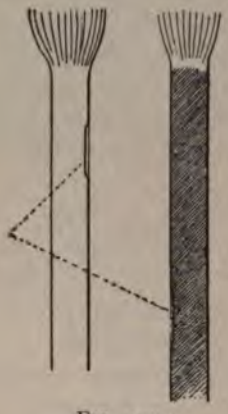


FIG. 1524.

FIG. 1525.

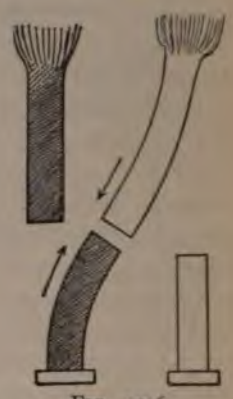


FIG. 1526.

A tendon receives nourishment from its muscle, its bone insertion, and *its sheath*, hence R. Jones, whenever possible, transplants the tendon sheath along with the tendon.

When exposing tendons through a long cutaneous incision it is not necessary to divide the fascia throughout the whole length of the wound; the fascial

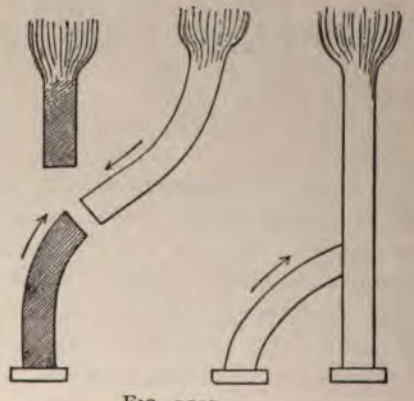


FIG. 1527.

FIG. 1528.

cut may be interrupted in places and thus union is rendered easier and more exact. The fascia should never be divided near its insertion into bone, otherwise union will be difficult.

Methods of Uniting Transplanted Tendons.—Most of what has been written as to the union of divided tendons is applicable here. Figures 1524

1536 illustrate sufficiently the usual methods of transplantation. In the ures the non-paralyzed muscle and tendon (the donor) are uniformly left ıshaded; the paralyzed muscle and tendon (the receiver) are shaded. Before plying sutures always vivify the surfaces to be united, and always pull up y "slack" there may be in the receiving tendon so that sufficient tendon

FIG. 1529.

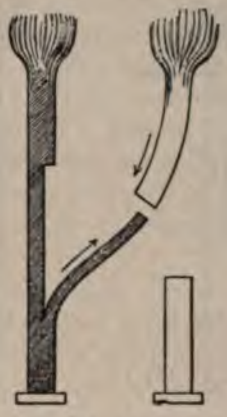


FIG. 1530.

FIG. 1531.

nseness is secured to permit of transference or application of muscle power the point of tendon insertion. A lax tendon between muscle and point of sertion is useless.

In Fig. 1526 the tendons both of the donor and of the receiver are com- etely divided and the peripheral portion of the donor is discarded, *i.e.*, none

FIG. 1532.

FIG. 1533.

FIG. 1534.

the normal function of the donor is retained. This procedure is justifiable ly when the donor is an entirely unimportant muscle or if, under the cir- mstances for which operation is undertaken, its normal action is objectionable. nctionally negligible muscles are rare, and unexpected evils are liable to follow

when even unimportant muscles are entirely cut off from their normal insertion. To obviate part of this, many devices have been suggested, and most of them will be easily understood after a glance at the figures.

Robert Jones believes that the union between the two tendons should be as near the insertion of the receiving (paralyzed) tendon as possible to avoid

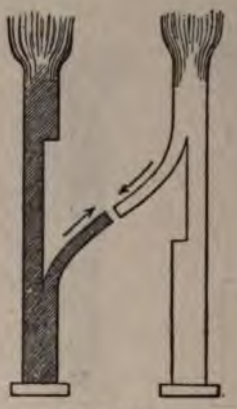


FIG. 1535.

FIG. 1536.

dangers from subsequent stretching of that structure. He prefers, if possible, to implant the end of the "donor" into the periosteum in a suitable place rather than into the tendon of the paralyzed muscle.

Lange in his transplantations makes free use of artificial tendons of silk.

Indirect tendon transplantation may be necessary when the donor is not long enough and when the ordinary methods of implantation seem inadvisable.

FIG. 1537.

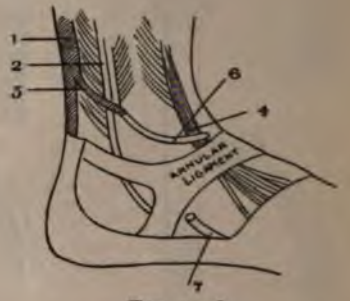


FIG. 1538.

1. Tendo Achillis. 2. Peroneus longus. 3. Peroneus brevis. 4. Extensor tendons. 5. Slip from tendo Achillis. 6. Tendon of peroneus brevis used as a graft.

Mainzer (quoted by Vulpius) used the following plan in a case of paralysis of the extensors of the toe: Form a slip from the tendo Achillis (Figs. 1537 and 1538); suture the end of this slip to an appropriate point on the peroneus brevis tendon. Divide the tendon of the peroneus brevis at such a place that a sufficiency of the tendon is left below the point of suture with the tendo

Achillis to reach from that point to the extensors which require strengthening. Pull this chosen portion of tendon centralwards out of its sheath and sew its end to the extensors (Fig. 1538, 6).

Closure of Wound.—Suture the wounded tendon sheaths with very fine catgut. Carefully suture the deep fascia with buried sutures. Close the skin-wound. Apply abundant dressings and a stiff bandage.

Several methods (apart from splints and apparatus) are available by means of which the transferred tendon may be protected from overstretching until such time as it gains strength. Hoffa exposed the completely paralyzed tendons which were supplanted by the operation and shortened them so that they could act as cords, keeping the limb in a position of overcorrection. Division or lengthening of the active opposing tendons which stretch the transferred tendon is harmless and useful. Robert Jones, in addition to the above methods, makes use of his "skin-flap removal" to secure uninterrupted continuity of the overcorrection.

After-treatment.—Keep immobilized for six weeks in simple cases, for eight weeks in cases where there has been much deformity, especially bony deformity, corrected. The period of rest is shortened if there is cause to fear adhesions, *e.g.*, if the tendon has been left outside the fascia or traverses an interosseous space. For a period of four weeks the patient ought to remain *in bed* to avoid any chance of injury to the lines of suture. After union is complete applications of moist and dry heat stimulate the circulation. Electrical stimulation is advantageous. Passive motion and, as soon as possible, gymnastic exercises are necessary. When the patient begins walking some simple form of supporting apparatus or boot will be necessary for a longer or shorter time.

Examples of Tendon Transplantation.

I. Talipes equinus—due to infantile palsy. The tibialis anticus and the extensor communis digitorum are alone affected. Power from the extensor proprius hallucis and from the peronei muscles may be transferred to the tendon of the paralyzed muscles. In all the operations for equinus it is presumed that any shortening of the tendo Achillis which obstructs overcorrection has been overcome by tenotomy or by tendon lengthening.

(A) Transplantation of a "slip" from the tendon of the peroneus brevis to the extensor digitorum.

Step 1.—From a point at least five fingers' breadth above the intermalleolar space make a median incision downwards. Curve the lower end of the cut slightly inwards. Divide the skin alone. In the subcutaneous tissue of the lower part of the wound lie the terminal filaments of the musculo-cutaneous nerve. Preserve these if possible.

Step 2.—Split the deep fascia throughout the whole length of the wound close to the tendons of the extensor digitorum and peroneus brevis which can be seen through the fascia. Separate the extensor digitorum from its surroundings for a short distance (Fig. 1539).

Step 3.—From a point slightly below the external malleolus make an incision upwards parallel to and about ½ inch behind the fibula for a distance of 5 inches. Incise the sheath of the peronei. Isolate the tendon of the peroneus

Step 3.—Retract the edge of the wound inwards. Expose the extensor proprius hallucis and its tendon. Split the tendon into an outer and an inner segment. Divide the outer segment transversely at the level of the annular ligament, so as to provide a tendon flap united to the muscle above and free below.

Step 4.—Isolate the tendon of the tibialis anticus and pull it upwards, flexing the foot dorsally. Make a longitudinal button-hole in the tendon. Pull the free end of the tendon flap (from the ext. proprius hallucis) through the button-hole and unite it there as in Fig. 1540.

II. Talipes Equinus Due to Infantile Palsy.

The tibialis anticus and extensor communis digitorum are paralyzed. The peroneus brevis is not available as a donor of power. The extensor proprius hallucis is healthy.

FIG. 1541.

FIG. 1542.

FIGS. 1541 AND 1542.—Tendon shortening. (*Labey.*)

Transplantation of a Slip from the Ext. Proprius Hallucis to the Extensor Communis Digitorum. Shortening of the Tibialis Anticus.

Step 1.—From a point at least five fingers' breadth above the intermalleolar space make a median incision downwards. Curve the lower end of the cut slightly upwards. Divide the skin alone. Preserve, if possible, the terminal filaments of the musculo-cutaneous nerve in the subcutaneous tissue.

Step 2.—Split the deep fascia. To the inner side of the tendon of the ext. communis, recognize and isolate the tendon of the ext. proprius hallucis.

Step 3.—Split longitudinally the tendon of the ext. proprius into an outer and inner segment. Divide the outer segment transversely at the level of the annular ligament (Fig. 1540).

Step 4.—Pull the ext. com. digitorum upwards, strongly flexing the foot. Make a longitudinal button-hole in this tendon and pull through the button-

hole the mobilized flap provided at the expense of the ext. proprius. Suture securely.

Step 5.—Retract the inner edge of the wound and expose the tendon of the tibialis anticus and shorten it in the same manner as the tendo Achillis is depicted as being shortened in Figs. 1541, 1542, 1543, 1544.

After any of the operations such as have been now described, Robert Jones endeavors to keep the united tendons free from tension by means of the removal of skin flaps. He writes: "Personally I see that the deformity of the foot is overcorrected before any operation is performed; and as soon as the

FIG. 1543.

FIG. 1544.

FIGS. 1543 AND 1544.—Tendon shortening. (*Labey.*)

tendon is transplanted, as in arthrodesis, I remove an oval skin flap from the paralyzed side so large that when the edges are sewn together the foot remains fixed in an overcorrected position. The removal of the skin flap, I venture to suggest, gives us considerable help in removing strain from the transplanted tendon. The foot by this means, as I have before said, remains in the desired position in spite of any outside influences." The reader will easily see how Jones's method may be applied to the operation here described and how valuable it is calculated to prove.

Regarding tendon transplantation in paralytic club-foot, Royal Whitman writes: "Tendon transplantation is most effective from the curative standpoint when but one muscle of the anterior leg group, for example an adductor or abductor, is paralyzed. The most common form of this milder type is paralysis of the tibialis anticus. As this muscle is the most powerful dorsal flexor and adductor of the foot its loss is followed by secondary equino-valgus. In Parish's operation the tendon of the adjoining extensor proprius pollicis was simply attached to that of the tibialis anticus, but as the extensor of the great toe is a very weak muscle, its power is hardly sufficient for the double task. A more efficient procedure is to split the tendon of the paralyzed muscle. The outer half is then separated from its muscular attachment, and the distal ex-

tremity is carried across the foot and is sutured to all the other tendons. The proprius pollicis is then attached to the inner half. In cases of longer standing and more marked deformity it is well to reduce the power of the abductors by cutting the tendon of the peroneus tertius from its insertion. This is then drawn beneath the other tendons and is attached to that of the tibialis anticus. All of the tendons on the front of the ankle may then be sutured to one another, so that all may act as direct dorsal flexors."

"The relative strength of the muscles, as well as their function, should be considered in selecting grafts, and in prognosis also. According to Fick, it is as follows, in kilogrammeters:

Back of the Leg

The calf muscle—gastrocnemius and soleus	8.21
Tibialis posticus	0.40
Peroneus longus	0.44
Flexor com. digitorum	0.37
Flexor longus pollicis	0.82
	10.24

Front of the Leg

Tibialis anticus	1.61
Extensor proprius pollicis	0.39
Extensor longus digitorum	0.72
Peroneus brevis	0.31
Peroneus tertius	0.20
	3.23

"The importance of the calf muscle on the back, and tibialis anticus on the front of the leg, is apparent. The former is nearly four times as strong as the combined posterior group, the latter equal to all the others on the front of the leg. It has been claimed that the transplanted muscle may become hypertrophied, and that its strength may increase sufficiently to carry out its new function, but this is somewhat doubtful."

III. The muscles of the calf are paralyzed. Talipes calcaneus has resulted. If the muscles are not hopelessly paralyzed, an application of Thomas' principles and prolonged immobilization of the leg with the foot in a position of plantar flexion may lead to regeneration. It is most important to rememeber this and to avoid immediate recourse to what may be a needless operation.

(A) Shortening of the tendo Achillis has been frequently employed (Willett, Gibney, and others). The methods of tendon shortening are sufficiently described (p. 1200). It is more logical, however, to supply new power to the tendon rather than merely to shorten it until it acts as a sort of passive support to the heel.

(B) **Transference of a Tendon Flap from the Flexor Longus Digitorum to the Tendo Achillis.**

Step 1.—From a point about 1 inch beow the tip of the internal malleolus make a 4-inch incision upwards midway between the tendo Achillis and the posterior border of the tibia. Expose the inner border of the tendo Achillis.

Step 2.—Split the tendo Achillis in such a fashion as to provide a flap, 2¼ inches long, free above and attached to the os calcis below.

Step 3.—Incise the deep fascia parallel and close to the poste of the tibia. Avoid injury to the sheath of the tibialis posticus vessels which lie posterior to the flexor digitorum and between flexor proprius hallucis. Expose and isolate the tendon of the fl digitorum opposite the internal malleolus.

Step 4.—Divide the tendon (flex. digit.) longitudinally into an a posterior segment. Leave the anterior segment intact. Divide th segment transversely low down so as to make it into a flap with pe

FIG. 1545.—Tendon transplantation. (*Berger and Bunset.*)

v. Vessels L.FL., Flexor longus. T.A., Tendon Achillis. 1. Intact portion tendon of 3. Flap from tendo Achillis. 3. Flap from long flexor.

Step 5.—Put the ankle in a position of great plantar flexion. L flaps obtained from the tendo Achillis and the long flexor alongside and unite them by sutures (Fig. 1545).

Step 6.—Shorten the intact portion of the tendo Achillis.

Step 7.—Close the wound. Dress. Immobilize in a position flexion.

(C) Transference of a Tendon Flap from the Peroneus Long Tendo Achillis.

Step 1.—From a point about 1 inch below the external malleolu 4-inch incision upwards between the fibula and the tendo Achillis.

Step 2.—Expose the outer border of the tendo Achillis and from i a substantial flap—about 2¼ inches long—above, united to the be

–Incise the deep fascia parallel and close to the posterior border
la. Expose and open the sheath of the peronei muscles. The
ıe p. longus lies posterior to that of the brevis. Fig. 1546.

FIG. 1546.—Tendon transplantation. (*Berger and Banzet.*)
longus. T.A., Tendon Achillis. C.P., Peroneus brevis. 1. Intact portion tendon peroneus longus. 2. Flap from peroneus longus. 3. Flap from tendo Achillis.

—Split the tendon into an outer and inner segment. Leave the
nent intact. Divide the inner segment transversely, low down
malleolus, so as to form a flap with its pedicle

—Put the foot in a position of equinus and
re. Lay the two flaps of tendon (from the
ngus and from the tendo Achillis) alongside
and unite them with sutures.
—Shorten the intact portion of the tendo

—Close the wound. Dress. Immobilize in
of equinus.
combination of operations B and C may be

nsference of slips from the tibialis posticus
us longus to the paralyzed tendo Achillis.
—Make the forked incision A B C D (Fig.
ffect the flaps A B C, A B D, C B D. In
preserve and retract the external saphenous
nerve which lie at the outer side of the tendo Achillis.
—Split the fascia so as to expose the outer edge of the tendo
Freely split open the sheath of the peronei.

FIG. 1547.—Tendon transplantation. (*Lucy.*)

Step 3.—Divide the tendon of the peroneus longus into an an posterior segment. The muscle fibres are inserted into the ten pennate fashion, therefore it is easy to continue the cut in the wards so as to form two muscular bellies each attached to a slip co half of the tendon (Fig. 1548). Carefully avoid injury to any nerv the muscle. Transversely divide the posterior slip of tendon as as possible.

Step 4.—Make a longitudinal cut into the outer side of the ten Retract the edges of the cut so as to form a gutter (Fig. 1548). I mobilized posterior segment or slip of peroneus tendon into the gu tendo Achillis and fix it there by sutures (Fig. 1549).

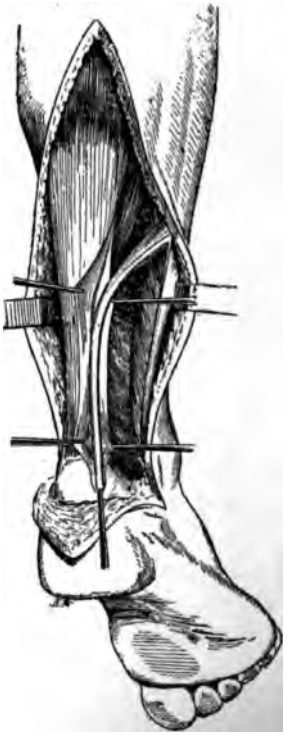


FIG. 1548.

FIG. 1549.

FIGS. 1548 AND 1549.—Tendon transplantation. (Lobey.)

Step 5.—Split the fascia on the inner side of the tendo Achillis the tendon outwards to expose the deep fascia under which can be seen tibial vessels and nerves. Split the deep fascia longitudinally inter vessels and nerves; retract these structures. This exposes the tibialis in the depth of the wound (Fig. 1550).

Step 6.—Isolate and split the tendon of the tibialis posticus; u of the segments into the tendo Achillis exactly as was done with the longus. During all these procedures the foot must be held in a positi corre

ep 7.—Close the wound. Dress. Immobilize in a position of over ction.

F) The flexor proprius hallucis may be implanted into the tendo Achillis n operation almost identical with that for the tibialis posticus, and im- ation of the peroneus brevis is almost identical with that of the longus.

I. The abductors of the foot (extensor communis digitorum, peroneus s and brevis) are paralyzed. The foot assumes the position of varus.

A) Transference of power to the peronei by means of a slip of tendon ed from the tendo Achillis. (The following description closely follows of Labey, "Chir. du Membre inférieur.)

FIG. 1550.

FIG. 1551.

FIGS. 1550 AND 1551.—Tendon transplantation. (*Labey.*)

lace the patient on his sound side in the latero-ventral posture. Flex g on the thigh. Have an assistant hold the foot.

ep 1.—From a point ½ inch below the level of the point of the malleolus, pwards midway between the posterior border of the external malleolus he external border tendo Achillis, to the level of the middle of the calf. se and retract, uninjured, the external saphenous vein and nerve.

ep 2.—Expose and free the outer border of the tendo Achillis. In the part of the wound expose the muscular belly of the outer head of the cnemius, and working from above downwards separate it from the soleus a point is reached where their fusion is complete and further separation possible. Relax the tendon by plantar flexon of foot.

Step 3.—With a knife split the tendo Achillis as in Fig. 1551. The slip of tendon is continuous above with the gastrocnemius, but is free from the soleus. Divide the slip of tendon transversely low down so as to convert it into a flap.

Step 4.—Divide the fascia covering the peronei muscles in the lower three-fourths of the wound. Isolate the peroneus longus (superficial) and the brevis (more deeply situated). Retract the tendon of the longus. The muscular fibres of the brevis are inserted into a flat tendon which is superficial to these fibres. Make a longitudinal split penetrating to half the thickness of the muscle and retract the edges of this split so that the peroneus brevis now forms a sort of gutter into which the tendon of the longus is permitted to fall (Fig. 1550).

FIG. 1552.

FIG. 1553.

FIGS. 1552 AND 1553.—Tendon transplantation. (*Labey.*)

Step 5.—Pull the mobilized flap of tendon Achillis through between the peroneus longus and brevis (Fig. 1552), and fix it there by sutures as in Fig. 1553. When bringing the tendon flap into position twist it carefully in such a fashion that its posterior surface (which has *not* been vivified or cut) lies against the cut surface of the soleus so as to avoid the formation of adhesions.

Step 6.—Close the wound. Dress. Immobilize in a posture of plantar flexion and outward rotation.

V. A finger flexor tendon is lost. Repair by transplantation.

v. Hacker ("Beiträge zur klin, Chir.," lxvi, Hft. 2, p. 279. Ref. "Journ. de Chir.," May 10, 1910) reports the case of a young girl who lost the flexor tendons of the middle finger as a result of a deep whitlow. v. Hacker operated as follows: He made a skin flap (Fig. 1554) which exposed the whole palmar aspect of the middle finger and showed the complete absence of the flexor tendons. Next he made two incisions (Fig. 1555) along the line of the extensor communis digitorum over the second metacarpal bone. Through these incisions

he split the tendon, forming a long flap of tendon having its pedicle near the base of the index finger. This flap he passed through a subcutaneous tunnel to the palmar aspect of the middle finger and sutured its end to the periosteum of the ungual phalanx. To avoid peritendinous adhesions he surrounded the transplanted tendon with a piece of freshly removed hernial sac and in the middle of the finger sutured across the tendon a band of fibrous tissue obtained from the débris of the tendon sheath destroyed by the whitlow. The wounds were sutured and healing took place by first intention. Sixteen days later

FIG. 1554.

FIG. 1555.

FIGS. 1554 AND 1555.—Tendon transplantation. (*von Hacker.*)

the stump of the old flexor tendon was exposed in the palm and sutured to the proximal end of the transplanted flap of tendon, which was of course, divided from its old connections on the dorsum of the hand. Closure of the wound and immobilization in a position of flexion was followed by healing. Eighteen months later the patient could close her fist completely.

VI. There is drop wrist due to musculo-spiral paralysis.

Tendon Transplantation in Musculo-spiral (Radial) paralysis. (Wrist drop.)—J. B. Murphy's operation has been described on page 806.

Robert Jones' Operation.—While most of the operations for wrist drop merely endeavor to apply power to the tendons of the extensors of the fingers (Murphy's method permits independent use of the thumb and index finger.) Jones' operation makes use of the pronator radii teres as a motor for the radial extensors and of the palmaris longus and flexor carpi-ulnaris for the extensors of the fingers, thus dissociating the movement of dorsal flexion of the wrist and dorsal flexion of the fingers.

Step 1.—Make a three inch incision in the middle of the radial side of the forearm along a line joining the styloid process of the radius and the external condyle of the humerus. Through this cut expose the posterior border of the supinator longus and retract this muscle forwards (*i.e.* ventrally). Recognize and retract dorsally the tendons of the extensor carpi-radialis longior and brevior, thus exposing the broad tendon of the pronator radii teres the sharp distinct upper edge of which is easily palpated. If the assistant pronates and supinates the forearm, recognition of the muscle is facilitated.

Step 2.—From the upper half of the tendon of the pronator make a flap with pedicle above (Figs. 1556 and 1557). Pass the flap through splits made in the tendons of the two radial extensors and fix it to these tendons by a few fine sutures. Close the wound.

FIG. 1556.

FIG. 1557.

FIG. 1558.

Step 3.—Make a four-inch incision parallel and internal (medial) to the radial artery beginning near the anterior surface of the styloid process of the radius and passing obliquely upwards and medially (Fig. 1558). Expose and free the tendon of the palmaris longus and divide it as low as possible.

Step 4.—Make an incision from the pisiform bone upwards for 2½ inches (Fig. 1558) and expose the tendon of the flexor carpi-ulnaris. Free the tendon and divide it at its carpal insertion. This step is difficult as the tendon is short and receives muscle fibres almost to its insertion. Protect the wounds and mobilized tendons.

Step 5.—Expose the extensor tendons of the fingers by a dorsal median longitudinal incision just above the wrist. Some surgeons use a horse-shoe incision and flap but this is unnecessary. With forceps make a subcutaneous tunnel from the dorsal wound around the radial side of the arm to the wound exposing the palmaris longus and pull the palmaris tendon through the tunnel. Make a similar tunnel round the ulnar side of the arm and through it pull the tendon of the flexor carpi-ulnaris.

Step 6.—Pass the tendon of the palmaris longus successively through button holes made in the extensor tendons of thumb and fingers and when it has gone through that of the little finger, suture its free end to the mobilized tendon of the flexor carpi ulnaris. With fine sutures unite the palmaris tendon to each of the flexor tendons where it passes through these. Of course the wrist ought to be dorsally flexed and the distal end of the extensor tendons ought to be on some tension when sutured. Mauclaire and Massart (La Pr. Med., May 1, 1919) recommend shortening of the extensor tendons by plication in many cases.

Step 7.—Close all the wounds without drainage. Dress. Immobilize in a position of dorsal flexion by means of Jones' "cock-up" splint. Figs. 1559, 1560.

FIG. 1559.—Dorsiflexed wrist splint to secure good grasp. (*Robert Jones, British Med. Journ.*)

FIG. 1560.—Dorsiflexed wrist splint applied. (*Robert Jones, British Med. Journ.*)

After Treatment.—Keep up hyper-extension (dorsal flexion) of the wrist and proximal phalanges for three weeks, but permit motion of the second and third phalanges. After about three weeks the splint may be removed and muscular education begun. It is well to remember Jones' warning against too early motion.

VII. *Claw Fingers "Griffe Cubital." Ulnar Paralysis.*—When the conductivity of the ulnar nerve is destroyed in the *lower* part of the forearm there results paralysis of the short muscles of the little finger with the palmaris brevis, the interosseous muscles of the hand, the two inner (ulnar) lumbricales, the adductor pollicis and the inner part of the flexor brevis pollicis. This paralysis of the extensors of the fingers, permits the flexors unopposed play so that the proximal phalanx assumes a position of hyper-extension while the two distal phalanges become flexed. The deformity is of course most marked in the ring and middle finger. If the lesion to the ulnar nerve is high up, then the inner half of the flexor profundus digitorum is also involved and no clawing of the fingers is produced.

The extensor tendons of the fingers pass from the wrist over the heads of the metacarpal bones, and each sends a slip of insertion to the bases of the first, second and third phalanges respectively. At the level of the metacarpo-phalangeal joint, a fibrous expansion passes from each side of tendon and joins perforating fibres of the palmar fascia. Fig. 1561.

These connections with the palmar fascia and the slip of insertion into the first phalanx limit greatly any action of the extensors, or the two distal phalanges. Extension of the two last phalanges is produced by the interossei and the lumbricales which are inserted into the extensor tendon below the articula-

tion. Thus the tendon of the extensor beyond its insertion into the proximal phalanx is activated by these small muscles, the action of its own proper muscle being checked by its insertion into the proximal phalanx and its connection with the palmar fascia.

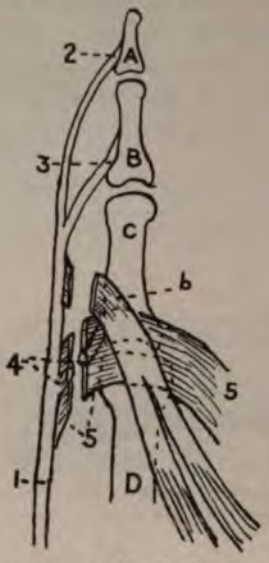


FIG. 1561.—*A*, *B*, *C*, Phalanges; *D*, metacarpus. (*After Le Fort.*)

1. Extensor tendon.
2 and 3. Insertion of tendon into distal and middle phalanges.
4. Divided insertion of tendon into proximal phalanx.
5. Divided lateral expansion which united the extensor tendon to the palmar fascia.
6. Tendons of the interossei and lumbricales divided near their insertion into the extensor tendon.

From the above anatomical facts Rene Le Fort (La Pr. Med., July 21, 1919) concluded that claw fingers due to permanent interruption of ulnar conductivity might be relieved by a simple operation provided always that the joints of the fingers remained supple. The whole operation consists in freeing the extensor tendons from their insertion into the proximal phalanges, from their connections with the palmar fascia and in dividing the insertions of the interossei and lumbricales muscles. If these obstructions are removed then the extensor muscle is free to activate its whole tendon and the deformity disappears.

Le Fort's Operation.—(There is marked "claw" of the little and ring finger.)

Step 1.—Make a dorsal incision along the extensor tendon of the little finger and a similar incision along that of the ring finger. The middle of each of these incisions is opposite the corresponding metacarpo-phalangeal joint.

Step 2.—Divide the interossei and lumbricales muscles at their insertions into the sides of the extensor tendons, Fig. 1561. Divide the anastomoses between the extensor tendons and the palmar fascia. Divide the band by which the extensor tendon is inserted into the base of the proximal phalanx.

Step 3.—Cover the deep surface of each tendon with a slip of rubber (from an old glove) to prevent reunion of the divided tendon and fascia.

Subsequent treatment consists in massage and methodical mobilization.

The operation seems both logical and easy.

FIG. 1562.—Davis' operation.

VIII. There is paralytic eversion of the leg necessitating the use of apparatus which must be fastened to a pelvic band. To obviate the necessity of apparatus G. G. Davis proceeds as follows:

(*a*) The Tensor Fasciæ Femoris muscle is *not* paralyzed. Make a vertical incision about 2½ inches in length down to the great trochanter near its anterior edge. From this cut elevate the periosteum backwards for a short distance. Undermine the skin anteriorly to the wound and expose the tensor fasciæ femoris at its insertion between the layers of the fascia lata. Make a flap of the

muscle with its pedicle above. Unite the free end of the muscle flap to the posterior (elevated) edge of the periosteal wound.

(b) The tensor fasciæ femoris is paralyzed Expose the trochanter major as already described. Undermine the skin forwards from the original incision, exposing the fascia lata. At an appropriate distance in front of the trochanter major incise (A B, Fig. 1562) the fascia parallel to the incision in the periosteum (C D), unite the posterior edge of the periosteal wound C D to the anterior edge of the fascial wound A B by the sutures xx′-yy′-zz′.

CHAPTER CVIII

TENOTOMY

There are two methods of performing tenotomy: (A) The open operation; (B) the subcutaneous operation.

(A) **Open Operation.**—Make an incision of sufficient length to expose the parts to be divided. Usually this cut is made parallel to the tendon. Isolate, by blunt and sharp dissection, the segment to be divided. Retract surrounding structures. Sever the tendon. Close the wound. If it is impossible or improper to isolate the offending structure, expose it by retracting

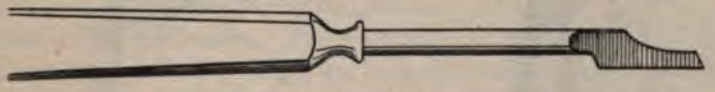


FIG. 1563.—Jones's tenotome.

the edges of the superficial wound, and then make the section, cautiously and with small cuts, under guidance of the eye.

(B) **Subcutaneous Operation.**—For this operation small, narrow-bladed knives (tenotomes) are necessary. Usually a sharp-pointed straight tenotome suffices, but a probe-pointed instrument is occasionally useful. The shorter and narrower the blade, the better it is, so long as it is sufficiently strong (Figs. 1563, 1564). The advantages of subcutaneous tenotomy are (*a*) diminished danger of infection; (*b*) absence of scar. The dangers of injury to neighboring important structures are slight, and in most localities easily avoided.

FIG. 1564. Tenotomes.

Tenotomy of Tendo Achillis (Achillo-tenotomy).—1. Cleanse the foot and leg, and turn them over on to the outer side. By palpation locate the most accessible part of the tendon. (The position of choice for section is ½ inch above the insertion in infants and 1½ inches in adults.)

2. Introduce a sharp-pointed tenotome through the skin under, *i.e.*, anterior to, the tendon. Keep the flat surface of the tenotome parallel to the tendon.

3. Turn the cutting-edge of the tenotome against the tendon.

4. Have the assistant flex the foot until the tendon is tense.

5. Press the tenotome against the tendon and by a slight levering motion divide it. Take care not to injure the skin.

6. Withdraw the knife after turning its blade once more parallel to the tendon. Apply dressings.

N. B.—Beginners frequently perforate the tendon with the tenotome and do not get complete division. Many surgeons in Step 2 pass the tenotome behind the tendon and cut forward; others, having made a passage along-side the tendon with the sharp-pointed tenotome, substitute a probe-pointed one for the division of the tendon.

When the tendo-Achillis has been divided in adults, the result is often mediocre or poor. Tendon lengthening is therefore preferable to simple tenotomy in adults. Toupet's method of operating is probably the best. Figs. 1566 and

FIG. 1566.—(*Toupet.*)

FIG. 1567.—(*Toupet.*)

1567 (La Pr. Med., Feb. 21, 1910) show clearly how the operation is performed. The after-treatment consists in immobilization for eight days. After 12 days walking with two canes is permissible. During the night some apparatus ought to be worn to prevent the weight of the bedclothes from causing recurrence of the equinus. Fig. 1568 shows Toupet's apparatus which consists of (*a*) a plaster of Paris belt applied above the knee and provided with two

FIG. 1568.—(*Toupet.*)

rings; (*b*) a strip of adhesive plaster round the foot and (*c*) rubber tubing to unite these two and so keep up dorsal flexion.

Tenotomy of Tibialis Anticus.—This tendon is usually divided near its insertion into the internal cuneiform. The surgeon stands on the opposite side of the leg to that of the tendon. The assistant grasps the leg and the foot in his hands. Abduction and plantar flexion demonstrate the position of the tendon.

Step 1.—Place tips of fingers on the opposite edge of tendon.

Step 2.—Introduce the tenotome through the skin a short distance from the proximal edge of the tendon.

Step 3—Change the direction of the knife and pass it horizontally over the tendon until its point is felt by the finger guarding the opposite side.

Step 4.—Have the assistant make the tendon tense (abduction and plantar flexion of foot).

Step 5.—Turn the edge of tenotome against the tendon and divide it.

Step 6.—Withdraw tenotome. Dress in a position of eversion.

Tenotomy of Tibialis Posticus.—Point of division should be about 1½ inches above the internal malleolus. The surgeon stands in same position as in tenotomy of the tibialis anticus. Demonstrate the tendon by abduction and plantar flexion of the foot.

Jacobson writes: "In fat infants it is often quite impossible to feel the tendon, and in these cases a spot midway between the anterior and internal borders of the leg will be the best guide, as denoting the inner margin of the tibia. The surgeon then introduces a sharp tenotome so as just to touch, if possible, the inner margin of the tibia, taking care to sink the blade sufficiently to open the sheath freely. This being done, a blunt tenotome is introduced through the same opening, and pushed under the tendon; the edge being then turned towards it, and the tibia used as a fulcrum, the tendon is severed, together with that of the flexor longus digitorum."

Division of Plantar Fascia.—The plantar fascia may be divided in several places: immediately in front of its origin from the os calcis; beside the transverse crease which is present in all marked cases of plantar contracture, or in any line which may seem suitable. Division in more than one place may be necessary before satisfactory results are obtained.

Step 1.—The assistant makes the fascia tense, and the surgeon, by palpation, satisfies himself as to its "geography."

Step 2.—A tenotome is introduced through the skin, at the inner side of the fascia (the fascia is not kept tense at this stage) and passed, with its flat surface parallel to the skin, between the skin and fascia across the sole until its point is beyond the outer edge of the fascia.

Step 3.—The cutting-edge of the tenotome is turned against the fascia, now made tense by the assistant, and this structure is divided.

Step 4.—The tenotome is withdrawn, suitable dressings applied, and the foot immobilized in a position of overcorrection.

Little's disease, spastic paraplegia.—A large proportion of children suffering from severe paralysis may be transformed into useful beings and enabled to walk with comparatively little deformity. Robert Jones writes regarding tenotomy of spastic muscle, "Empiricism has taught us that for some reason or another tenotomy lessens, both in frequency and intensity, the spasmodic element in paraplegia. I do not merely mean to say that division of the tendo Achillis controls spasm in the calf muscles, although of course it does, but rather that spasm in which those muscles are not directly concerned is also influenced." * * * "The practical deduction from these observations is, that no opportunity should be lost of performing a tenotomy. Even in mild cases, where a spastic tendon is to be felt, we need have no hesitation in dividing it.

require division. To anyone who has practised the operatio
attempts to divide the muscles effectively subcutaneously, v
Division is followed with but little hemorrhage and the wound
out drainage. Having exsected the pieces of the adductors ea
is divided, or, better still, elongated, for we often note that aft
tendon outright, there is a tendency to walk too much on the he
splints are then applied to the foot. The limbs are then well a
surgeon notes whether there is any obstacle to easy extension
there should be (it is not often the case), an open incision must
side of the popliteal space and the tense hamstrings are in turn c
incisions are long enough the fascial contraction can be attack
for it is here that opposition is found. I would discourage the u
incision, as when adopted it often seriously hampers the su
fully extend the knee by reason of the strain cast upon the
division, however, with fasciotomy, usually suffices to allow c
and excision of tendons could do no more. In 1885, when I w
Hospital, there used to be an adult diplegic always at the gate
tor, and on two or three occasions I took him in to try and st
tracted limbs. On one occasion I removed about an inch from
strings, but he was mentally so deranged that we did not d
credit. I mention the fact, however, because Lorenz of V
recently written on the advantage of exsecting portions of

"We have now presumably got our patient stretched com
abduction frame, and we must keep him there for three montl
heal very rapidly and suppuration has occurred in the adducto
occasions only, despite the insanitary position of the wounds a
operations performed; for instance, in 1890 I operated on 27 p
may be taken as a fair index of my yearly return. At the end

for the first two weeks, frequently during the day, abduction, adduction, flexion and extension of the hips should be practised This should be done with and without resistance. At night time the feet should be attached to the side of the bed, in order to obtain abduction. After the first few days of this later stage of treatment the splints should be removed twice a day and the muscles well massaged, and both active and passive movements of ankles, toes, knees and hips, encouraged. Any movement executed in a jerky style should be practised until perfected.

"The little patient may now try to walk. It will be noted that one of the difficulties of an untreated spastic when he tries to walk, is the narrowing of the pedestal upon which the trunk rests by reason of adducted limbs. Operation has now overcome this, and with abducted limbs the body is poised upon a pedestal that is widened. During early straining the nurse must see that while walking the limbs are not approximated, and that from the first swinging, aided by crutches, must be prevented. Crutches should not be allowed until the patient has been taught to stand unsupported. I need not enter into any more details regarding this most important stage of treatment, but would add that it affords an inexhaustible field of ingenuity, and that upon the intelligence and industry of the nurse very much depends.

"I cannot now deal with individual cases, but I may say that I have operated upon cases from 12 months to 20 years of age. A large number of these were so bad that they had never attempted to place one foot before the other. Some were structurally flexed (contracted) at ankle, knee and hip. A most helpless youth of 20, one limb across the other, was able in six months to stand erect and walk with sticks, and twelve months later was able to move his limbs north, south, east and west with hardly an appreciable jerk. Success in an ancient case where so much has to be unlearnt, and where the mechanical stage offers so much difficulty, proves the soundness of the principles I have endeavored to expound. It is logical to infer that if old neglected cases are amenable to surgical education, our prognosis should be very hopeful in the young.

"With regard to the degree of benefit to be derived from treatment, the parents should be given to understand that, under favorable conditions of nursing and tuition, the child, aided by the hand or sticks, will be able to walk distances in from twelve months to two years, and that with perfectly straight limbs and heels on terra firma. A large proportion of cases will, later on, manage aided by one stick. Even in the least successful cases parents, mostly having despaired, are full of gratitude. The mental condition of the children obviously improves when their physical defects are remedied, and they are enabled to mix with their little friends. Complete recovery in spastic paraplegia is, of course, impossible.

"It will be gathered from my remarks that the treatment of spastic paralysis should resolve itself into a system. That system involves operative, mechanical and educational stages. The treatment cannot be separated into parts. If the surgeon is not satisfied that the case is to be under his control for twelve months he will consult his reputation best by leaving it alone. Operations, not followed up by careful and prolonged after-care, give rise to disappointment and

discredit. Merely dividing tendons and trusting to massage and electri futile and dispiriting."

Foërster's operation for spasticity and the principles enunciated by are referred to on page 771.

CLUB-FOOT

A clear distinction must be drawn between congenital club-foot an form which results from paralysis acquired before or after birth. In the f when correction or rather overcorrection of the deformity has been com

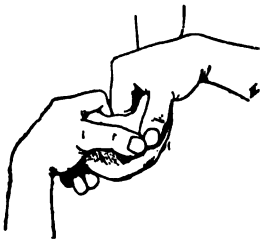


FIG. 1569.

FIG. 1570.

FIGS. 1569 AND 1570.—Manual correction. (*Berger and Banzet.*)

and established, all has been done; in the paralytic form *after* deformity has corrected it may be necessary to resort to tendon transplantation, etc., bef satisfactory result is obtained.

Congenital Club-foot.—*Talipes Equino-varus.*—Many cases of equino-v may be successfully treated without operation if taken early enough. I intelligent mother or nurse by manipulation endeavors to mold the defo

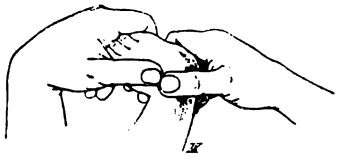


FIG. 1571.

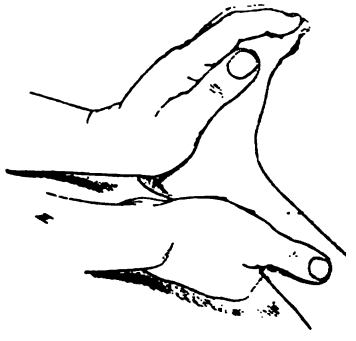


FIG. 1572.

FIGS. 1571 AND 1572.—Manual correction. (*Berger and Banzet.*)

foot into good shape (unwind the deformity), and does this patiently 3 or 4 t daily, a cure will often be obtained. Figures 1569, 1570, 1571, 1572, show the modeling, molding, or unwinding ought to be done. In other case surgeon may attain the same result more rapidly by forcible rectificatio one or more sittings), and by keeping the foot in the corrected or overcorre position by means of a plaster-of-Paris dressing until the new position is established.

A cardinal rule is that overcorrection must be obtained, otherwise relapse is the rule; but overcorrection is not all. "*No case of club-foot is cured until the patient can voluntarily raise his own foot from the deformed into the over-corrected position.* There are three causes of so-called relapse in club-foot: (1) Insufficient correction of deformity. (2) Erroneous deflection of body weight on tarsus when walking. (3) A slack and lengthened condition of muscles due to overstretching'' (Robert Jones).

Forcible Rectification.—The necessary force may be applied either by the hands or by a wrench. Tenotomy of the tendo Achillis is usually, and of the plantar fascia frequently, a necessity immediately before the forcible rectification.

Manual Rectification.—*Step* 1.—Grasp firmly in one hand the heel and ankle, in the other the distal end of the foot, leaving the region of the calcaneo-

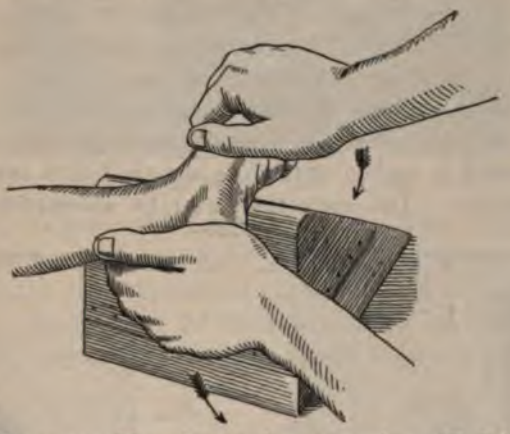


FIG. 1573.—Manual correction over wedge. (*Hoffa.*)

cuboid articulation unsupported by the hands. Lay the convex surface of this portion of the foot against the edge of a wedge of wood covered by a towel. The wedge acts as a fulcrum (Fig. 1573).

Step 2.—Apply force, even the whole weight of the body, to straighten or unfold the foot by compressing its convex side against the fulcrum and stretching or tearing the structures on the concave side. In young children overcorrection is often possible in one sitting. Care must be taken not to tear the skin. If the skin seems about to tear, put off further correction until another time, when it will be found to have accommodated itself to the changed circumstances. If the desired result is not obtained in one sitting, a second, third, or fourth operation should be done at intervals of about a week.

Before the anesthetic is discontinued, envelop the foot in a plaster-of-Paris dressing. To avoid trouble from swelling of the foot owing to the trauma it is well to keep the limb elevated for twenty-four hours.

Remember that Overcorrection is the Aim.—Ridlon always uses forcible rectification with tenotomies, and division of fascia and ligaments as may be required. He says, "Put on thick layers of cotton batting with bandage over—this must be smooth, so as to prevent ridges being formed on inside of the plaster

which is now applied *thick*—so thick that patient may walk on it for four or five months. Don't change the dressings. Don't operate before the walking age. Sometimes the thick bandages will come off, *i.e.*, slide off. If this is the case, smoothly pad the lid of a cigar box fashioned to shape of sole and fix it to the foot by adhesive straps, then apply the plaster. The whole foot and leg is wrapped with the cotton before the wood foot-piece is applied. The plaster goes to

FIG. 1574.—Thomas's wrench.

about the knee and must be thick. The test of cure is that when the plaster cast is removed the foot remains in overcorrected position and cannot without force be put into malposition. Operate at any age."

Instrumental Rectification.—The best instrument for applying force in the rectification of club-foot is Thomas' wrench (Fig. 1574) employed as Thomas used it. The wrench is applied to the foot and the foot is twisted and bent in the normal directions. The correction must be accomplished forcibly and

FIG. 1575.

FIG. 1576.

FIGS. 1575 AND 1576.—Jones' club-foot splints.—(*Jones.*)

quickly and the foot immediately released. Holding the foot too long in the bite of the wrench may result in a pressure sore (Ridlon and Jones). Apply force sufficiently to temporarily destroy the resiliency of the soft parts so that the foot lies lax in the hand of the operator. Place in good position in a retention brace. After a few days the resiliency of the soft parts begins to return and the operation is repeated if this is necessary to obtain overcorrection, until there is no tendency towards recurrence. After this keep the foot immobilized until all the

parts have adapted themselves to their new relations; or, as Thomas said, "until slack has been taken up and the flexors and evertors of the ankle voluntarily act." Ridlon writes: "If the patient cannot voluntarily flex and evert, it is because the tendons concerned are still suffering from stretch palsy, and relapse

FIG. 1577.—Application of Jones' splints. (*Jones.*)

will occur exactly as deformity arises in poliomyelitis. (Figures 1575, 1576, 1577, show the application of R. Jones' iron club-foot splints.)

In some obstinate cases of club-foot the tendo Achillis pulls upwards on the *inner* side of the tuberosity of the calcaneum to an unusual extent and thus hinders or prevents correction of varus. Under these circumstances R. Jones

FIG. 1578.

FIG. 1579.

FIGS. 1578 AND 1579.—Jones' transplantation of insertion tendo Achillis.

by transplantation moves the insertion of the tendo Achillis outwards in the following manner: Expose the tendo Achillis by a T-shaped incision (Fig. 1578). Split the tendon longitudinally. Separate the inner half of the tendon from its insertion. Pass the inner segment of tendon (now a flap with pedicle above) under the outer (Fig. 1579) segment and suture its free end to the periosteum of

Jonas's Operation.—A. F. Jonas ("Annals of Surg.," April, 1899) thus describes his method: "An incision is made, beginning slightly below the margin of the plantar fascia on the inner side of the foot, at a point on a line directly below and anterior to the internal malleolus, extending forwards and upwards to a point on the first metatarsal bone and nearly to the metatarso-phalangeal articulation. A second incision is made, beginning at a point over the astragalo-scaphoid articulation, extending forwards and slightly downwards, joining the first incision near the metatarso-phalangeal joint, forming a V (Fig. 1581). The incisions are made deep, so as to include the subcutaneous tissues and fat." Dissect back the flap thus outlined. Sever *diagonally* the inner fasciculus of the plantar fascia. Divide the remaining structures successively, as directed by Phelps. Do not injure the astragalo-scaphoid capsule. Make another incision on the outer side of the foot over the head of the astragalus, and with

FIG. 1581.

FIG. 1582.

FIGS. 1581 AND 1582.—Jonas's operation. (*Jonas.*)

a chisel divide the neck of the bone, if necessary, removing the head. Overcorrection is now easy. Ligate the bleeding points. Replace the triangular flap (Fig. 1582). Do *not* suture. Cover the wound with perforated oiled silk. Dress. Immobilize in a plaster-of-Paris bandage which reaches one-third up the thigh. Leave dressings undisturbed for five or six weeks. This method is only suitable in "old, inveterate, and relapsing cases."

Lorenz (König, Lehrbuch der speciellen Chir.," iii, 809) gives the following list of operations for club-foot, in which the bones are attacked:

(A) Osteotomies.
  (1) Linear division, navicular bone from the sole (Hahn).
  (2) Linear division, tibia and fibula above the ankle.

(B) Enucleation.
  (a) Of one bone:
    (3) Of the cuboid (Solly).
    (4) Of the astragalus (Lund, Mason).
    (5) Of the astragalus with resection of the point of the external malleolus (Mason, Ried).
    (6) Curettement of the spongy part of the astragalus, leaving the articular surfaces intact (Verebély).

(7) Of the astragalus plus removal of a wedge with base e from the anterior process of the calcaneum (Hahn).

Meussel's operation of extirpation of ossifying centres of the astrag young children.

(*b*) Of several bones.

(8) Enucleation of astragalus and cuboid (Hahn, Albert) and navicular bone (West).

(9) Enucleation of the navicular and cuboid (Bennet).

(C) Resections.

(10) Of the head of the astragalus (Lucke, Albert).

(11) Of a portion of bone from the external half of the neck astragalus (Hueter).

(12) Resection of a wedge from the outer and upper sides tarsus (O. Weber, Davis, Colley, R. Davy, Schede, M etc.).

(13) Resection of two wedges perpendicular to each other witl bases directed outwards from the astragalo-calcanea Chopart's joints (Rydygier).

Occasionally the fibula occupies a position too far back near the tendo lis, the space between the internal and external malleoli is too narrow, an anterior portion of the astragalus is too wide. This state of affairs is an in tion for excision of the astragalus (König).

Astragalectomy.—1. Apply an Esmarch bandage.

2. Make a longitudinal, slightly curved incision 2 inches long over the prominent part of the head of the astragalus from the external malleolus d wards and inwards between the outermost tendon of the extensor longus itorum and the peroneus tertius. Reflect the soft parts with a perio elevator.

3. Open the ankle and astragalo-scaphoid joints. Seize the bone wi lion-jawed forceps, loosen it with an elevator, and divide its ligaments strong, blunt-pointed scissors or the scalpel.

4. Place the foot in good position. If correction cannot yet be obtained, may follow Walsham's advice (Jacobson's "Operations of Surg.," ii, 711): "W once a bone operation has been embarked on, it is no use stopping short sufficient bone has been cleared away to permit of the rectification of the f No more should, of course, be removed than is necessary, but to take away little is to my mind the graver fault."

Cuneiform Tarsectomy.—The operation of cuneiform tarsectomy con in making a longitudinal incision over the most prominent portion of the tar without injury to the tendons, in reflecting the soft parts to lay bare the b and in excising a wedge of bone. The steps of the operation do not req description; the surgeon must apply Walsham's rule, quoted in the pre paragraph, and also make use of common sense.

Ogston's Operation ("Brit. Med. Jour.," June 21, 1902).—This opera is similar to that of Meussel, and is suitable in bad cases of club-foot in chil up to the sixth or possibly the eighth year. A skiagraph will tell if ossifica

has proceeded too far. The principle of the operation is to remove the osseous centres from those bones which impede rectification. After correction, the remaining envelope of cartilage will become ossified. "An incision through the skin is made in a gentle curve, beginning in front of the external malleolus and extending forwards with its convexity towards the sole, until it terminates over the calcaneo-cuboid joint on its dorsal aspect. When its edges are retracted, the outline of the astragalus is visible. The soft parts covering it and the cartilaginous shell surrounding its osseous centre are then divided by a shorter incision in the same line as the cutaneous one, the knife being made to sever every thing down to the bony kernel. A Volkmann's spoon, slightly curved forwards at its neck is passed into the wound of the cartilage, and its whole bony centre, save the upper part constituting the pulley between the two malleoli, is cautiously scraped out." If necessary, the same treatment may be applied, through the same external wound, to the cuboid and anterior end of the os calcis. After removing the Esmarch constrictor and attending to hemostasis, close the wound with deep and superficial sutures and immobilize with plaster of Paris in correct position.

The following remarks are based on material placed at the disposal of the writer by his friend, Robert Jones, of Liverpool.

Before any bone operation is adopted in club-foot one should, at a preliminary sitting, correct the deformity as much as possible by means of the tenotome and wrench. Less bone will then have to be removed and the result is much more artistic.

In club-foot there is often present a twist in the leg. This rotation is entirely below the knee and confined to the tibia and fibula. Unless this deformity is corrected there will be persistent trouble even after complete correction of the equinus and varus. "It is therefore well to anticipate this problem the moment we begin treatment. Every time the Equino-varus is manipulated the malleoli should be grasped in one hand, while the leg should be held below the knee with the other. The lower ends of the tibia and fibula are rotated outwards and the knee inwards. The leg is thus twisted on its long axis by an action not dissimilar to that used when one wrings a wet cloth. If this is done each day, by the time the foot is straight the inversion of the foot will also have disappeared. No club-foot can be pronounced cured until the patient walks. Walking is the act which completes the cure."

Sometimes osteotomy or osteoclasis is necessary to correct the twist in the tibia and fibula.

Robert Jones sums up his practice in the treatment of club-foot in the following words:

"The operation I perform in obstinate cases is very simple and can be completed in about ten minutes.

"(*a*) The removal of half the scaphoid.

"(*b*) The removal of anterior and lower part of astragalus leaving the tibial articulation.

"(*c*) Osteotomy, if necessary, through outer part of tarsus.

"(*d*) Forcing foot into everted position when the scaphoid will articulate with the remainder of the astragalus.

"The simple case is one which we can quite easily replace in good position and which shows but little, if any, adduction at the mid-tarsal joint. Such a case will probably not require a division of even the tendo Achillis. If, however, there is marked adduction at the mid-tarsal and a rotation inwards of the tibia and fibula, the case may be looked upon as affording the surgeon an opportunity for work. In the simple case, where the surgeon cannot pay frequent visits, the nurse should be taught the manipulations which she can practise several times a day. The tibia and fibula should be grasped at the epiphysis which may otherwise easily be separated and the foot should be alternately everted and flexed. Following this, the heel should be grasped in one hand and the anterior portion of the foot in the other and abduction secured at the mid-tarsal joint. Five minutes spent three times a day in doing this should be followed by gentle massage of the flexors of the foot and the peroneal group. This should be followed by the application of a bandage or of a rectangular splint.

FIG. 1583.—Treatment of club-foot by bandages. (*Jones.*)

Surgeons often fail to appreciate how much can be done by the simple application of a calico bandage. If the surgeon desires to turn the foot in, he should start the bandage on the outside; if he desires to evert the foot he should begin on the inside. In the case of eq. varus he should start on the inner side of the ankle, pass under the sole of the foot, over the front of the ankle and so evert it. Every turn of the bandage so applied pulls the foot outwards, whereas, if the bandage be started from the outer side, the deformity is at each turn increased. I have on several occasions, for demonstration purposes in club-foot of moderate severity, quite overcome and cured the deformity by the simple expedient of a bandage. Care should be taken if a bandage be used, with or without a splint, not to carry it much above the ankle lest the muscles be thereby weakened (Fig. 1583). Should the surgeon be able with but little effort to restore the foot to its normal position, it will not be necessary to divide a tendon. Should the degree of resistance be more marked, division of the tendo Achillis becomes

imperative. A great deal has been written of the advantage of correcting the varus before dividing the tendo Achillis. Although in full possession of the arguments for this view, I quite fail to appreciate their force, and on the contrary maintain that the Achilles tendon often helps to perpetrate the inversion.

"The Club-foot Shoe.—I use a club-foot shoe which I have modified from the Thomas. The details of its application, simple as they appear, require study. It can be made by any country blacksmith at a very trivial cost. It is made of flexible sheet-iron (Figs, 1575, 1576, 1577). After the foot has been manipulated into the best possible position, a piece of plaster should be started on the dorsum, passed under the sole, and given to an assistant at hand. He should be directed to pull at right angles to the leg, while the surgeon places the retention splint in position. This should be done for fully six weeks, either by the surgeon or someone he can trust; the splint being changed every day. I very much prefer this method of retention to that of plaster of Paris which I rarely use. At the end of two months the most troublesome of this class, *i.e.*, cases which the surgeon sees during the first two years, will present a pliable foot which can be placed into normal position without encountering resistance, and if the child be sufficiently old he can be taught to walk in such a manner that each step he takes tends to improve the shape of the foot."

Talipes Calcaneus (Congenital).—In this form of club-foot the foot is in a position of dorsal flexion; the tendo Achillis is elongated, the anterior tendons are contracted. It is wise to begin treatment by manipulation a few days after birth. The manipulation consists in patiently and persistently coaxing the foot into a position of plantar flexion, thus stretching the anterior tendons. As soon as the deformity has been *over*corrected, apply some fixed dressing to retain the overcorrected position until the tendo Achillis has had time to contract. In severe cases the manipulation may be carried out forcibly under an anesthetic. Tenotomy of the anterior tendons is very rarely necessary.

Talipes Cavus (Hollow-foot).—The arch of the foot is unnaturally high; the anterior part of the foot being approximated to the heel. The worst samples of the deformity are those produced as a mark of beauty in the Chinese women of high rank. Talipes cavus may occur along with the other forms of club-foot. Operation is only required in severe cases and consists of subcutaneous division of the plantar fascia, forcible rectification and retention in a plaster-of-Paris dessing, until such time as the corrected position is established. Ducroquet ("La Presse Med.," July 23, 1910) finds that in *talipes cavus* associated with equinus the foot can be extended (dorsal flexion) to a right angle with the leg but cannot be flexed. When the foot is at right angle to the leg the inferior surface of the first metatarsus makes a prominence on the sole of the foot. The great toe is hyperextended on the metatarsus. Ducroquet believes that it is the lowering of the distal end of the first metatarsal which gives the foot its hollow form, and that this lowering of the first metatarsal and the hyperextension of the corresponding toe, are both due to paralysis of the short flexor of the toe permitting the long extensor of the toe to overact. Hence he operates as follows:

1. Make a longitudinal dorsal incision from the middle of the first metatarsal bone to the middle of the proximal phalanx of the great toe. Expose the long

extensor tendon. Divide the tendon. Suture the proximal tendon st the distal part of the first metatarsus. Close the wound.

2. Correct the rest of the deformities in the usual manner by subcu division of the plantar fascia; tenotomy of the tendo Achillis, etc.

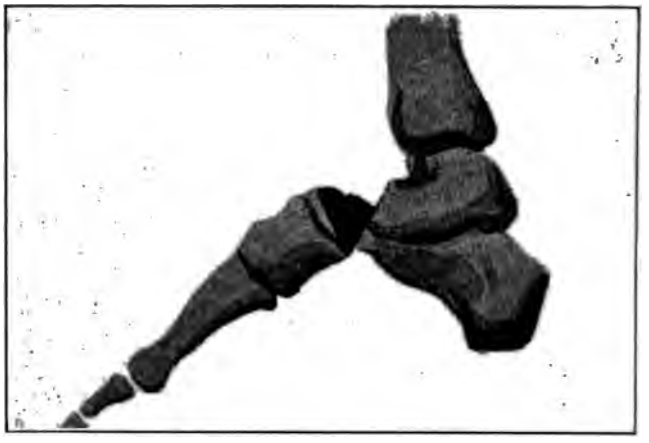


FIG. 1584.—Jones' operation talipes calcaneo-cavus. (*Jones.*)

Arthrodesis for Paralytic Calcaneo cavus.—Robert Jones' Operation.

I. Paralysis of the calf muscles is complete.

Operation in two stages, four weeks intervening.

Stage I.—*Step* 1.—If the plantar fascia is contracted, divide it subcutan and straighten the sole as much as possible by manual or instrumental

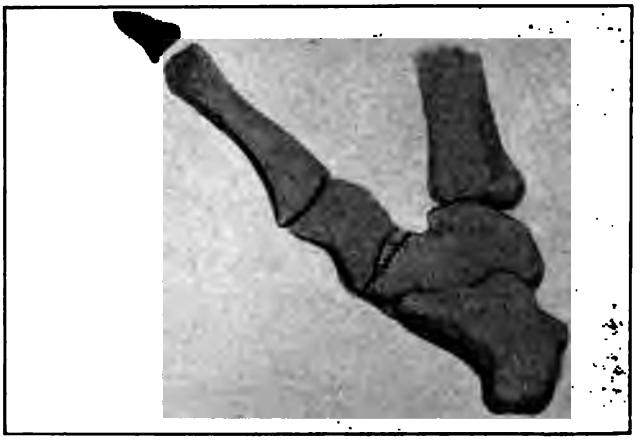


FIG. 1585.—Jones' operation talipes calcaneo-cavus. (*Jones.*)

Step 2.—On the inner side of the foot make a 3-inch incision to the bone centre of the cut being opposite the angle of convexity. Separate the parts from the tarsus with an elevator until the inner, dorsal, and pl surfaces are accessible.

Step 3.—With a chisel remove a wedge of bone (base above) (Fig. 1

rt Jones, "Am. Journ. Orthop. Surg.," April, 1908) large enough to com- correct the cavus.

p 4. Close the wound. Correct the cavus by flexing the foot dorsally (585) and after applying dressings bandage the foot to the tibia. The is cured, but the calcaneus is apparently much worse.

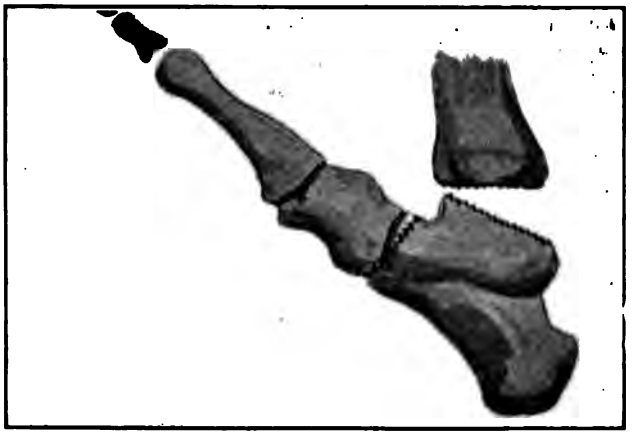
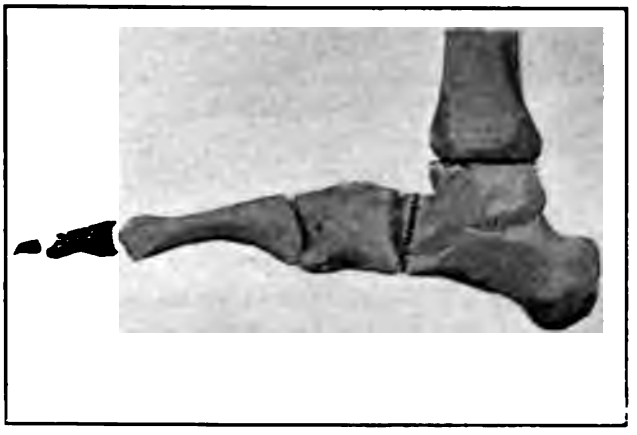


FIG. 1586.—Jones' operation talipes calcaneo-cavus. (*Jones.*)

ge II.—Four weeks later.)

p 1.—Make a longitudinal cut at the back of the heel, the centre being ite the ankle-joint. Open the joint.



[illegible]

Stage I.—As in previous operation.

Stage II.—(Four weeks later.)

Step 1.—Opposite the ankle-joint make a posterior transverse incision long enough to expose the posterior capsule of the joint. Reflect the skin upwards and downwards. Place and hold the foot in good position. Shorten the elongated posterior capsule by throwing it into folds and fixing the folds by sutures.

Step 2.—Shorten the tendo Achillis.

Step 3.—Excise enough skin from the upper and lower edges of the transverse incision so that when sutures are introduced and healing has taken place the skin itself will aid in maintaining the correct position.

Step 4.—Apply dressings. Immobilize. After three weeks begin massage of the gastrocnemius. "For some weeks after walking has commenced the foot should be protected against strain."

CHAPTER CIX

CONTRACTURES

Dupuytren's contracture is due to a contraction of the palmar fascia whereby the fingers become fixed and incapable of extension. The ring finger is first affected. The fascia is normally connected by bands with the skin of the palm. When the fascia contracts, the skin, being adherent to it at points, is naturally thrown into wrinkles and folds. Operation is indicated when the deformity causes distinct disability. In a handicraftsman operation will be called for at a much earlier stage of the disease than in one whose work does not demand free use of the hands.

Adam's Operation.—Clean the hand thoroughly. Note the points where the skin is *not* closely adherent to the subjacent fibrous band. At such places introduce a fine tenotome between the skin and the fibrous band. Turn the edge of the tenotome against the fibrous hand. Make the band tense by extending the affected finger, and at the same time give a slightly sawing motion to the tenotome. Be careful *not* to cut too deeply lest the flexor tendons be injured. The operation must be repeated at several points. Apply aseptic dressings. Fix the hand and fingers in a position of extension by means of a dorsal splint. After the lapse of three weeks careful and thorough massage is indicated; the splint may be discarded during the day, but a suitable appliance to maintain extension must be worn at night for several weeks.

Recurrence of the trouble often takes place, but in other cases the result is permanent and various nodes of scar tissue or callosities disappear in a surprising manner. The operation is simple, can be performed under local anesthesia, and ought to be tried in most cases before more severe measures are adopted.

Dupuytren's Operation.—Cleanse the hand thoroughly. Extend the affected finger as much as possible. Make a transverse incision one inch in length opposite the metacarpo-phalangeal joint. This incision divides both the skin and the contracted fascia, but *must not* injure the flexor tendons. Apply aseptic dressings. Fix the hand and fingers in a position of extension

by means of a suitable splint. When the wound has healed, the treatment to be adopted is the same as after Adam's operation.

Open Operation, Hardie's Operation.—"An incision begun half an inch above the principal transverse fold of the palm, immediately over the tense bridle of fascia, proceeding to the finger mainly involved. This is carried along the bridle to a little beyond the base of the last phalanx which is affected. The lips of the incision having been opened up, the knife is then carried close to bridle along its whole extent so as to separate from it the adjacent skin, cellular tissue, and fat, first on one side and then on the other. In doing this it is necessary to go some depth near the upper end of the incision, so as to divide the little bands which attach the web of the finger to the processes of fascia inserted into the sides of the first phalanx." Cut across the tense fascia at the digital end of the incision. Make further transverse incisions opposite the middle of the first and second phalanges as may be required. Divide the fascia transversely wherever it seems to prevent complete extension of the fingers. Isolated portions of fascia *may* be removed if convenient. Close the wound with sutures after attending to hemostasis. Apply aseptic dressings and bandage to a straight splint. After the wound has healed, make use of massage and retain the splint for two or three weeks.

Excision of the Diseased Fascia.—Complete excision of the diseased fascia is impracticable, but an extensive excision is both practicable and beneficial. Several methods of operating have been devised. Some surgeons advise the formation of a **V**-shaped flap having its base towards the fingers; others advise a straight longitudinal incision over the most prominent cicatricial band. Each method is proper in suitable cases. Whichever incision is used, the scar tissue is exposed as completely as possible by reflecting the skin in the manner described in Hardie's operation. The cicatricial tissue is divided at its insertion into the phalanges, carefully dissected from the subjacent structures, and removed if possible in one piece. Hemostasis is attended to and the wound closed. If the **V**-shaped incision has been used, the flap thus formed will generally be found incapable of completely filling the bed from which it was removed, so that it is necessary to close the proximal end of the wound as if it was a linear incision. The resulting scar is **Y**-shaped.

J. D. Griffith excises the cicatricial tissue through a longitudinal incision as described above, but instead of at once closing the wound, he adopts the following procedure: From the end B (Fig. 1588) of the longitudinal incision A B he makes the curved incision B C through the skin, and thus forms the flap F, with its base A C. In the same manner he makes the flap E, having its base at B D. These flaps are reflected from the subjacent tissues and turned so that the end of the flap E covers the raw surface left by the reflexion of the end of the flap F, and the end of the flap F covers the raw surface left by the reflexion of the end of the flap E (Fig. 1588). Whether the transposition of the skin-flaps is of much value or not, the method has given good results in the hands of Griffith, and in one case in which the author used it the result seemed excellent. In most cases, however, any attempt to transpose the skin-flaps is unwise, as the skin is so thin and ill-nourished that death of the flaps is very likely to ensue.

Lotheissen's Operation.—("Centralblatt f. Chir.," 1900, No. 20.) the curved incision A, B, C (Fig. 1589). Reflect the palmar flap thus o Excise the palmar aponeurosis. Extend the fingers. Replace the flap. the fingers extended there will be a small defect (AB) where the edges wound do not come together. Apply sutures as shown in the figure Esmarch bandage is used to permit of bloodless, careful dissection. the flap is replaced, hemostasis must be most carefully attended to, as cutaneous hematoma or the application of a compressive dressing en the vitality of the flap.

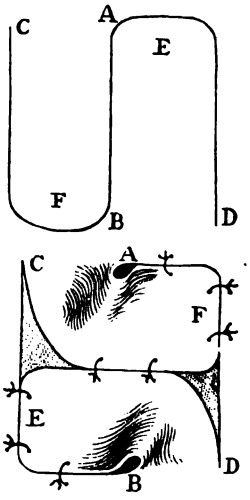


FIG. 1588.—Griffith's method.

FIG. 1589.—Lotheisen's operation.

Bruce Gill's Operation (Annals of Surg., Aug., 1919).—Do *not* use a t quet. Make a transverse incision along the distal palmar crease. Th this incision expose and excise the palmar fascia without button-holdi skin or injuring the underlying tendons, etc. (If the proximal interphal joint cannot be extended, excise the head of the first phalanx through a verse dorsal incision.) Obtain a free flap of fat from the thigh and in smoothly under the palmar skin. Close the skin incision. Dress. A splint for about one week.

Volkmann's Contracture.—Shortening of forearm to obviate effects contracture.

Step 1.—Make an incision for 13–14 cm. (5–5½ in.) upwards fro base of the styloid process along the outer side of the radius. Separa flexor tendons from the bone and retract them forwards and inwards alon the radial artery. Retract the supinator longus backwards.

Step 2.—Expose the radial insertion of the pronator quadratus and it close to the bone. Separate this muscle from its anterior and posteri nection but not from the ulna.

Step 3.—Cover the lower part of the wound with gauze. Expose and the insertion of the pronator radii teres in the outer surface of the mid radius. Endeavor to supinate the forearm. If supination is

complete divide with a knife (hugging the median border of the radius) the radial attachment of the interosseous ligament near the middle of the forearm. This permits complete supination ("Jean Berger, Journ. de Chir.," May, 1912).

Step 4.—Excise a segment of radius ½ to 1 inch in length near the insertion of the pronator radii teres. This may be done subperiosteally with a Gigli saw.

Step 5.—On the ulnar side of the arm make an incision from about ¾ inch above the styloid process for about 18 cm. (7 inches) along the surface of the ulna. Separate the flexor tendons from the bone and pass a blunt hook from the ulnar to the radial wound so as to elevate all the soft parts anterior to the pronator quadratus. Excise the pronator quadratus completely.

Step 6.—Using as a measure the segment of radius which was excised in Step 4, excise a similar segment of ulna from a point near the insertion of the pronator quadratus. It is important that the wounds of the radius and ulna should not be at the same level.

Step 7.—Unite the two fragments of the radius by means of chromic catgut, wire, or Lane's plate. Do the same with the ulna.

Step 8.—Close the wounds in the soft parts. Apply dressings. Apply a moulded plaster-of-Paris splint (or any suitable splint) from well above the elbow down to near the tips of the fingers. The forearm should be semiflexed and completely supinated. The wrist and fingers should be extended and the thumb left free. There must be no constriction anywhere.

In a child the splint may be removed at the end of a month, though before that it may require readjustment and the arm may be temporarily exposed for the use of passive movements.

Tendon lengthening, in place of bone shortening, has given some excellent results.

CHAPTER CX

PRINCIPLES OF PLASTIC SURGERY

Plastic operations are such as are undertaken to close up or fill defects resulting from errors in the development (hare-lip, etc.) or from the destruction of tissues by disease, operation, or accidental injury. While plastic operations are applied to each and every kind of tissue (bone transplantation, tenoplasty, etc.), yet in most of them the skin plays the chief rôle.

Do not undertake plastic operations in the debilitated, or in those with active disease present (*e.g.*, suppuration, syphilis, etc.).

The two main principles at the base of all plastic work are: (*a*) Proper preparation or vivification of the tissues to be united; (*b*) thorough relief of tension. Failure to carry out these principles leads to certain disappointment.

When the defect is oval, but not very extensive, and the neighboring skin is not firmly bound to the deeper structures, the edges of the oval may be brought together directly and sutured. If on attempting approximation *tension* makes itself evident, this tension must be relieved. Tension may be relieved by burrowing with knife or scissors between the skin and the deep fascia, thus

undermining the skin all around the defect (Fig. 1590). In some localities, *e.g.*, the pectoral region, very large defects may be thus obliterated. Often this burrowing must be supplemented by making a cut through the skin parallel to and on one or both sides of the defect. Such relaxation incisions should be in positions where their scar will be more or less hidden. Figs. 1591 ①; ②, ③, ④, ⑤, ⑥ indicate how various defects may be closed. Large defects require other means of treatment, either being closed by skin-

FIG. 1590.

grafting or by the use of pedunculated flaps of healthy skin, obtained preferably in the near neighborhood, occasionally from more remote parts. The skin chosen to form the flaps must be such as to match that lost. It would not gratify a patient much to have a successful rhinoplasty performed on him if the hairy scalp was used to supply the necessary skin for the nose. The objection to many of the operations for ectopia vesicæ or

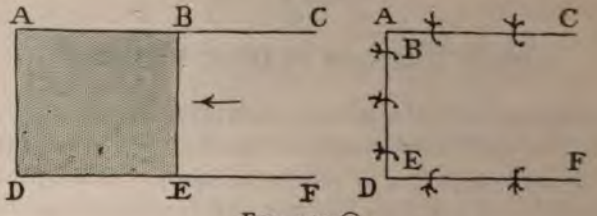


FIG. 1591①.

for epispadias is that skin capable of growing hair is used to line the new bladder or urethra. Hairless skin is often used to replace lost mucous membrane, but if healthy mucous membrane can be obtained, such is far better. The flaps should consist of the whole thickness of the skin, but without too much subcutaneous fat attached to them; they ought to be about one-sixth larger than the defect they are to fill, and should have a pedicle through which nourishment is freely supplied. This advice has been universal but Gillies considers it wrong. Twisting of, or tension on the pedicle occludes its blood-vessels, cutting off nourishment and impeding the natural drainage; hence it is necessary in tracing out the flap to do so in such a position that it can be fixed

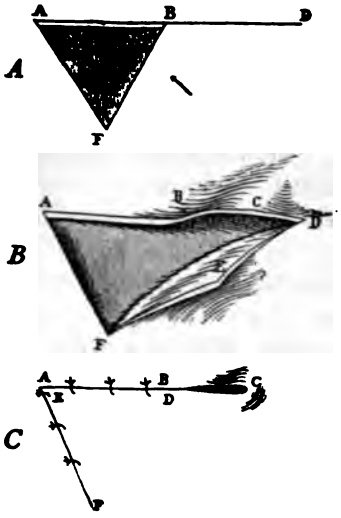


FIG. 1591③, A, B, C.

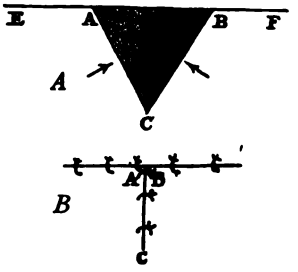


FIG. 1591④, A, B.

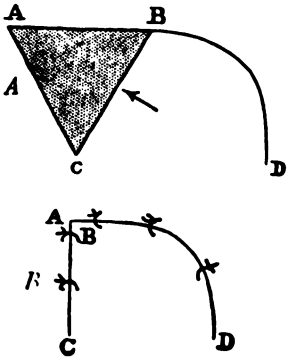


FIG. 1591⑤, A, B.

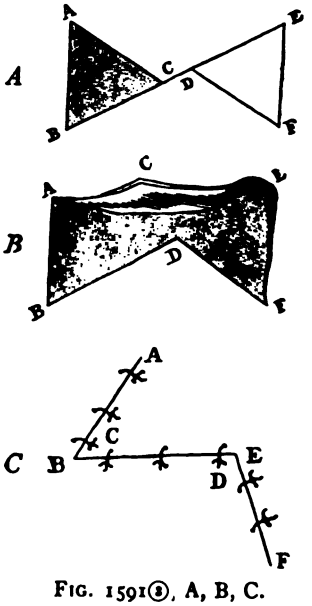


FIG. 1591⑧, A, B, C.

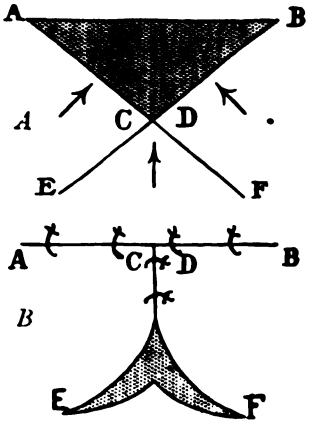


FIG. 1591⑥, A, B.

in its new location without running these hazards. Part or all of a even with a good pedicle and with its raw surface in contact with a co ing healthy raw surface, often fails to live. After the lapse of a few surface becomes discolored, edematous, blisters form, and death of all t takes place. This death is *not* from want of nourishment; it is from normal absorption or drainage from the flap. The drainage is of e importance than the nourishment obtained through the pedicle. Un lar circumstances a flap of skin completely detached from the body planted into a defect (Wolf's grafts) lives and does not show the ab nomena. This is due to the fact that there is no damming up of lym detached portion of skin. The grafted skin soon becomes united t bed, thus obtaining a sufficiency, but not an excess, of nourishment Mayo scarifies the surface of flaps which are provided with pedic providing for immediate lymph drainage and avoiding the dangers of from lymph stasis. This scarification need not mere scratches suffice.

FIG. 1592.

Sometimes flaps are provided with two p "visor-shaped" flaps. A good example of this v seen in Regnier's operation for cancer of the lower

Fear may be entertained as to the viability of it is transferred to its new site as soon as it is for thus in some cases it is wise to trace out the flap, it from the deep structures, but leave it attached ends; the bridge of skin thus formed must separated from the subjacent tissues by a layer of oiled silk. Afte two or three weeks one of its pedicles is divided and the flap put (Fig. 1592). This plan (Croft's) is specially suitable when the flaps are long and narrow.

W. D. Gillies (Surg., Gyn. and Obst., Jan., 1920) from his vast ex at Sidcup during the war has modified and improved the use of flaps the tubed pedicle. The use of these flaps will be described as for f formities, but they may be used elsewhere as efficiently.

Step 1.—From an unscarred place on the upper part of the neck m parallel incisions about three inches apart, downwards on to the ch undermining mobilize the skin leaving it attached at its upper and lo (Figs. 1593 and 1594). Partly divide the upper end of the pedicle thus Fold the pedicle transversely on itself to form a tube with the epidermis Suture together the edges of the skin of the tube. By undermining use of relaxation and other sutures close the wound from which the was raised. Apply dressings. Anytime after the lapse of three w further stages of the operation may be begun.

Step 2.—(A) There is a comparatively small area to be repaired, e the chin. Excise all the scar tissue of the area. Divide the distal end of the pedicle. Undo the tubing of that end of the pedicle by the suture line and any core of scar tissue which may have formed in tube. This end of the pedicle when spread out suffices to fill the defect

chin. Suture the new formed flap in its new position under slight tension. (Figs. 1593–1594).

(B) The defect is larger. There is not sufficient material in the tube to fill the defect. At the end of the pedicle trace on the chest wall an area of skin sufficient to fill the defect and dissect it free leaving it attached to the pedicle. Use this flap to fill the defect.

(C) During tubulization of the pedicle nourishment is obtained from both ends. If it is feared that the neck end of the pedicle will not transmit enough nourishment when the chest flap is mobilized so as at once to cut off all its connections except with the pedicle, then it is wise to undermine all the area

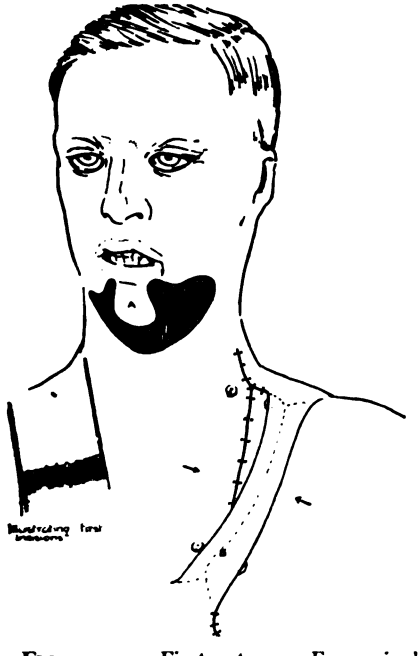


FIG. 1593.—First stage: Four inch parallel chest flap tubed. Complete closure by advancement. *(Gillies, Surg. Gyn. and Obst.)*

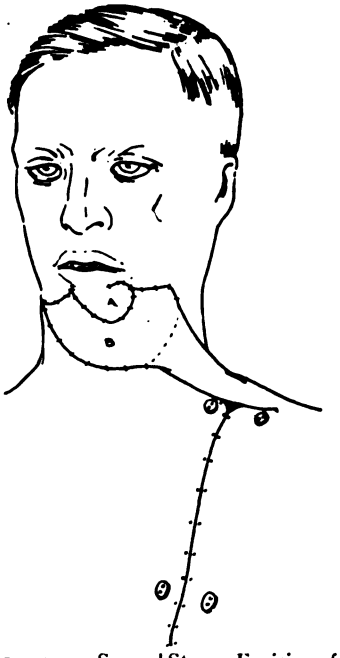


FIG. 1594.—Second Stage: Excision of scar tissue for reception lower extremity of flap B. Flap A swung to left. Chest flap partly untubed and sewn into place. (Drawn by Lieut. Lindsay, A. A. M. C.) *(Gillies, Surg. Gyn. and Obst.)*

destined to form the flap but to leave its distal portion continuous with the surrounding skin. The part of the flap nearest the pedicle may be tubulized. In a few days the flap will become accustomed to its lessened blood supply and its distal connections can be divided.

(D) Instead of undermining the flap trace it out by incising the skin all around it, only dissecting the flap free after a few days.

(E) Two tubed pedicles may be employed for one flap (Figs. 1595 to 1599).

(F) After forming one tubed pedicle as above but before dividing its chest connection Gillies has deliberately divided its base and implanted that base into a more vascular region. He has found this shifting of the base of supplies useful.

FIG. 1595. FIG. 1596.

FIG. 1595.—Cordite burn, soon after injury in battle of Jutland. (*Gillies, Surg. Gyn. Obst.*)

FIG. 1596.—Healed with very severe ectropion and upper facial burn. Bilateral pedicles to chest flap, first stage. (*Gillies, Surg. Gyn. and Obst.*)

FIG. 1597. FIG. 1598.

FIG. 1597.—Second Stage: Pedicles and flap in position. (*Gillies, Surg. Gyn. and O*

FIG. 1598.—Third Stage: Pedicles opened and returned to chest. Note developm facial expression, a free blush was present in this flap in the third week. (*Gillies, Surg and Obst.*)

Step 3.—The flap has been swung into position to fill the defect and has nited in its new site.

FIG. 1599.—Six months after first operation. Note grafts to eyelids and adaptation of flap to new position. Artificial eyebrows. (*Gillies, Surg. Gyn. and Obst.*)

FIG. 1600. FIG. 1601.

FIG. 1600.—Total facial cordite burn. Battle of Jutland. (*Gillies, Surg. Gyn. and Obst.*)
FIG. 1601.—Large chest flap applied to face with two tube pedicles. The skin over the ose has sloughed. The left pedicle has been divided. (*Gillies, Surg. Gyn. and Obst.*)

(A) Divide the pedicle close to the face and replace it in the opened out ound of the neck.

(B) Divide the pedicle at its base on the neck and use it for repairi parts of the face or nose (Figs. 1600 to 1606.)

Step 4.—Consists of various minor or "touching up" operations the new material as comely as possible.

FIG. 1602. Fig. 1603.

FIG. 1602.—Both pedicles divided. Note ectropion of eyelids. (*Gillies, Surg. Obst.*)

FIG. 1603.—Method of converting the left pedicle into a nose. A suitable epith was provided for the new lip and alæ. (Drawing by Prof. H. Tonks.) (*Gillies, S and Obst.*)

FIG. 1604.—Left pedicle swung to the nose. (*Gillies, Surg. Gyn. and Obst.*

The "tubed flap" may be well used in repairing or replacing a lo or lower lip. In this case the flap is not to be untubed or spread out folded condition it provides an epithelial lining both towards the mo externally as well as a smooth lip margin.

Dufourmentel's Operation ("Journ. de Chir.," xv., 171, 1920) is example of plastic surgery. Where the whole chin and horizontal ram lower jaw has been destroyed Dufourmentel operates as follows:

Stage 1.—*Step* 1.—Restore the floor of the mouth by flaps taken f cheek (Fig. 1607).

Step 2.—Make two parallel incisions through the whole thickness of the hairy scalp from one temporal region to the other. The resultant flap ought to be about 3 inches (7–8 cm.) wide. Elevate the flap from the skull and pull it forwards and downwards (Fig. 1608) over the face like a loop or a visor.

FIG. 1605. FIG. 1606.

FIGS. 1605 AND 1606.—Final Stages. The right pedicle has been spread over the chest. The new nose has been trimmed and supported by cartilage. Four new eyelids have been provided by an outlay' operation. New eyebrows have been grafted.

FIG. 1607. FIG. 1608.

Suture the flap to the reconstituted floor of the mouth. Do not try to give any particular or esthetic shape to the flap. That can be done later. All that is desired at present is to provide abundant and living skin and mucosa (Fig. 1609).

Stage 2.—After *at least* two weeks divide and replace the pedicles and endeavour to fashion reasonably esthetic lips.

(B) Divide the pedicle at its base on the neck and use it for repair parts of the face or nose (Figs. 1600 to 1606.)

Step 4.—Consists of various minor or "touching up" operations the new material as comely as possible.

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Stage 1.—*Step* 1.—Resto cheek (Fig. 1607).

Stage 3.—From the lower end of the remnants of the ascending ramus of the jaw on one side make a tunnel between the flap forming the lining of the floor of the mouth and that forming the skin of the chin etc., to the lower end of the ascending ramus of the jaw on the other side. Through this tunnel pull a bone graft obtained with its periosteum from the tibia. The graft must be broken in two places to give it the necessary shape. Suture the ends of the graft to the remnants of the ascending rami. When the new bone has become consolidated in place, a series of small 'touching up' operations will be necessary. The result in one of Duformentel's cases is shown in Fig. 1610.

Gillies ("Plastic Surgery of the face," Oxford Press, 1920) has performed similar operations.

Remarks.—To the author it seemed that the new lining for the floor of the mouth, being obtained from the cheek, would be entirely unsuitable because of the hair, but Dufourmentel in a letter says "I have never bothered myself fighting against the development of hair on the cutaneous flaps included in the buccal cavity x x x the hairs cause absolutely no disability. When their length becomes annoying the patients themselves trim them with scissors. The results of the operation have remained excellent."

Instead of pedunculated flaps, areas of skin entirely detached from their normal connections may be used. This is truly skin-grafting. The grafts may be obtained from the patient himself, from a recently amputated healthy limb, or from obliging friends. Autogenous flaps are the best. If the grafts are homogenous it is advisable to choose a donor having blood belonging to the same class as that of the recipient (p. 860). Grafts obtained from animals (rabbits, frogs) have been employed, but when used after the Thiersch method, even if they have adhered to the raw surface, they have not reproduced epithelium and have been ultimately absorbed.

Wolf's Grafts.—Wolf, of Glasgow ("Brit. Med. Journ.," Sept. 18, 1875), devised the following method of repairing recent defects, especially in the eyelids:

On some suitable region—the forearm, inner side of upper arm, or thigh—trace with the scalpel an area of skin at least one-sixth larger than the defect to be filled and of suitable shape. Quickly and completely separate the flap outlined from the subjacent tissues. With the scissors carefully remove all fat from the under surface of the graft; in fact, trim this surface until the pale, deep surface of the cutis vera is visible. Fit the graft into the defect and hold it accurately in place, either by a few fine sutures or by suitable dressings. In the repair of defects in the eyelid the writer has often seen the Wolf graft sutured in place and protected by a few layers of gold-beater's skin, which, when dry, acts as an efficient splint to the part.

Grafts such as above are usually employed to cover raw areas resulting from operations and not to cover granulating surfaces. It is of prime importance that hemorrhage be completely stopped, otherwise effused blood will lift the graft from its bed and prevent adhesions. H. D. Gillies (Surg., Gyn. and Obst., Feb., 1920) emphasizes the following points. (1) The graft should exactly fit the defect. (2) The skin edges should be accurately sutured. (3) Moderate tension is advisable as it keeps open the tiny spaces through which anastomotic processes may occur and tissue fluids come and go. (4) Pressure should be

kept up on the graft to keep it firmly pressed on its new bed until adhesion takes place. Application of pressure is easy on the forehead.

"On the nose one method entails the use of a molded splint made of dental modelling composition, which is in its turn held in place by strapping by a spectacle frame, or best by a splint taking its fixation point from the upper teeth. On the cheek and chin, pressure is applied with difficulty. In any case a dental appliance carrying an arm to press the mold on to the graft is indicated. Further, a splint fixing the mandible in the open bite position will inhibit most cheek movements, while the head itself may be secured by a jury mast. Another and effective method of graft fixation is illustrated in Fig. 1611, in which

FIG. 1611.—Wolfe graft to chin, "Stent" or dental mold composition pressing the graft to it's bed. (*Gillies, Surg. Gyn. and Obst.*)

a large Wolfe graft was applied to the lower lip and chin, and pressed there by a mold of dental composition, which is itself fixed by cross sutures from areas beyond the margin of the graft. In Fig. 1611 little rolls of gauze were used to prevent cutting through of the retaining sutures."

Large Wolfe grafts may be used and are specially good applied to the forehead. Pedunculated flaps are better for nose and cheek repair.

Thiersch's Graft.—Thiersch ("German Surg. Soc.," 1874, 1888) suggested the use of grafts consisting of epidermis, corresponding in thickness to the covering of a blister and cut from some suitable region in as large strips as possible. This is the most common and convenient method of skin-grafting. The grafts may be applied to a fresh wound, *e.g.*, open wound left after amputation of the breast, or to any clean granulating surface. When a granulating surface is to be covered by grafts, it must be prepared by thorough cleansing and the removal of exuberant granulations by means of rubbing with gauze or by the sharp spoon. All bleeding must have ceased, whether the wound is recent or granulating. If oozing of blood persists, the wounded surface must be covered by a protective layer of rubber tissue, silver-foil, or such like material, over which sterile gauze is applied, and the skin-grafting put off until the next day.

The grafts are generally obtained from the inside of the thigh. If the skin to be employed is hairy, shave the hair. As the portion of epidermis to be taken is

too thin to contain any hair-bulbs, no hair will be grafted, no matter from what region the graft is obtained. Cleanse the area selected. With the hands, McBurney's tractor, or a paper-knife make the skin tense. Shave off the thinnest possible layer of epidermis with a very keen razor, moistened with salt solution (Halsted uses an amputation knife). This forms the graft and should be as large as possible. Carry the graft, lying in folds on the razor blade, to the wound. Keep it moist with salt solution. Hold the sharp edge of the blade close to the wound. With a needle pull the end of the graft gently on to the wound, temporarily fixing it there; as the blade is slowly pulled away parallel to the wound the graft smoothly slips off it and lies flat on the wound. If there are any little folds in the graft, get rid of them with needles in the same manner as is done when spreading sections of tissue on the slide for microscopic work. Sometimes if the graft becomes tangled on the razor blade it is well to put it in a basin of salt solution and float it on to a piece of oiled silk. The oiled silk with the

FIG. 1612.

graft lying smoothly on it is laid (with the graft under) on the wound, the edge of the graft is held in place on the wound with a needle, and the oiled silk removed gently, leaving the graft in the position desired.

When the whole wound is covered with grafts, place over them strips of rubber tissue, of silver-foil or of cotton mesh impregnated with rubber or celloidin and outside this the ordinary gauze dressings. The dressings ought, if possible, to remain unchanged for a week. No antiseptic lotions ought to be employed, only salt solution. The same kind of dressings must be applied until the healing process is complete. Very large surfaces can be made to heal in a short time by the Thiersch method of skin-grafting.

When possible it is far better to avoid the use of any dressing or tissue applied to the grafted area which should be left freely exposed to the air. To protect the wound against flies and mechanical irritation, it may be surrounded by a thick wall of cotton or such like material which supports a roof of fine wire netting (mosquito screen) (Fig. 1612). Some surgeons have advised the use of a plate of celluloid instead of the wire netting, but this prevents the desired free circulation of air.

Carl Haeberlin (Bad Nauheim) finds that all granulating wounds heal best when exposed to the direct rays of the sun (without any interposed material) for about two or three hours daily; during the rest of the day he covers the wounds loosely with gauze ("Münchener med. Woch.," 15 Oct., 1907).

The original method of skin grafting is that of Reverdin ("Soc. de Chir.," Paris, 1869). It consists in transplanting fragments of skin about the size of the head of an ordinary pin; the fragment includes a little of the *cutis vera*. Numbers of the grafts are implanted on the area to be covered and each if it lives acts as a centre for the growth of epithelium. Thiersch's method has practically displaced Reverdin's.

Denuded areas on the hand or forearm may be covered with skin by the following efficient but distinctly uncomfortable method: If the defect is on the back of the hand or forearm, choose a place on the front of the abdomen or chest where the hand or forearm may lie and be supported without too great strain. Through the skin of the trunk make two parallel incisions and undermine the skin between them, thus forming a flap with two pedicles (Fig. 1613).

FIG. 1613.

Push the hand under the flap and adjust and suture the flap to the denuded area. Apply dressings, and with adhesive plaster fix the hand and arm to the trunk. When union has taken place between the flap and the denuded area, divide the pedicles, close the abdominal wound in the usual manner, trim the flap, and complete its union to the denuded area. If the denuded area is on the palmar aspect of hand or forearm, the flap must be made on the back of the trunk.

In cicatricial ectropion of the eyelids, Gillies (personal communication) uses a modification of Esser's method of utilizing Thiersch grafts. The upper lid is taken as an example; its skin surface has been burned and the resultant scar tissue has everted the lid.

Step 1.—Make an incision immediately above the ciliary margin from one canthus to the other. Insert a horse hair suture through the edge of the lid and use this to pull the lid downwards. As traction is applied scar tissue bands become prominent. Divide these horizontally until the eversion is entirely overcome. (It is usually necessary to undermine the skin of the eyelid upwards and downwards from the incision.)

Step 2.—Mould a piece of dental composition to fit the raw area created in the eyelid. This mould must conform to the contour of the eyeball, terminate in a rounded point at each end and be of such a shape and size that the edges of the skin wound may be sutured over it. Dry the mould after it has been "set" in cold water.

Step 3.—Cut a Thiersch graft and wrap it *smoothly* around the mould. Trim away any excess of graft as any overlapping of the epithelium is objectionable. Be sure that the epidermal or superficial surface of the graft is next the mould.

Step 4.—Pass two horse hair sutures from one skin edge to the other of the incision but do not yet tie them. Place the mould with its covering of graft, into position in the wound and have the assistant tie the two sutures already in place. This step is delicate as it is important that the graft be not disturbed and that there be neither wrinkles, nor folds in it. Complete the closure of the skin wound over the mould and graft. After the lapse of 8 or 10 days reopen the wound completely and permit the lid to drop to the position into which it was lowered in Step 1. The former raw surface is now firmly and completely covered with epithelium, Fig. 1614. Further treatment consists in dry cleanliness followed later by massage which aids in smoothing the lid.

FIG. 1614.—Illustrating functional cure of ectropion. (*Gillies, Surg., Gyn. and Obst.*)

In cases of X-ray burns E. G. Blair (personal communication) has had much success from skin grafting. He carefully excises the affected area of skin *plus* the subjacent fat so that the deep fascia is exposed. After this he sutures the skin edges to the deep fascia (with interrupted stitches of catgut) all round the defect until little or no fat is visible. The result is a depression the floor of which consists of the deep fascia and it is easy to cover this floor with Thiersch's skin grafts.

WRINKLES

Passot (La Pr. Med., May 12, 1919) has published the experience of Morestin, de Martel and himself regarding operative effacement of wrinkles. The lessons taught by such work may have broader application. Most of the wrinkles on the cheeks as well as those external to the eyes (crows feet) and naso-labial folds can be lessened or obliterated by excising a fold of skin in the pre-auricular region. Figure 1615 shows the chief site for operation as well as some other sites where subsidiary work may be done.

The Operation.—At a point above and in front of the tragus pinch a fold of skin between finger and thumb and so find how much must be excised in

order to remove the deformities. The direction of the long axis of the fold must also be noted. Mark the contours of the fold with a dermatographic pencil and also mark the points where the principal sutures should enter and emerge.

FIG. 1615.—(*After Passot.*)

Usually the area of skin to be removed forms an ellipse with its long axis running obliquely upwards and forwards, the ellipse being from 3 to 4 cm. long by 1½ to 3 cm. wide. The area is often an ovoid with the narrow end anterior.

First neatly excise the skin of the selected area and then, *separately*, the subcutaneous fat. This precaution is taken so as more easily to avoid penetration of the aponeurosis under which lie branches of the facial nerve. Attend to hemostasis and close the wound with interrupted sutures. Probably an intradermic continuous suture would be best. Both sides should be operated on at the same sitting.

CHAPTER CXI

METHODS OF DRAINAGE

The collection of fluids in dead spaces in wounds is potentially dangerous, and hence drainage should be provided for such spaces. Collections of pus or other noxious fluids in any part of the body require removal, usually by means of drainage. Drainage in its simplest form is exemplified by the open treatment of wounds; here absorbent dressings are applied directly to the wound surface or cavity and absorb all exuded fluids as soon as secreted. Where dressings cannot be applied directly to the secreting surfaces, the secretions must be guided to the dressings. According to the nature and surroundings of the fluid to be drained, the method of drainage provided must vary. For such fluids as serum, capillary drains suffice; for thick pus, tubular drains are essential. When a collection of pus is evacuated through the peritoneal cavity, the method of drainage must provide protection to that cavity, hence a combination of tubular or capillary drainage with protective packing becomes necessary. The following are the principal means of drainage:

A. **Capillary Drains.**—1. *Horse-hair; silkworm-gut; catgut.* A few strands of these materials, in a bundle, act as an efficient drain for small quantities of serous exudates.

2. *Gauze* or *wick.* A strand of absorbent gauze or a portion of lampwick may be used as a capillary drain, but if these are left in place too long, fluids readily coagulate in their meshes, and instead of draining, they act as a plug to prevent drainage.

3. *Cigarette drains* consist of gauze surrounded (Fig. 1616) by a sheet of thin

rubber tissue which enhances their efficiency and prevents the gauze becoming adherent to surrounding structures. Instead of rubber tissue the gauze may be surrounded by a split rubber tube (Fig. 1617). Strands of woolen yarn are more efficient than gauze.

B. **Tubular Drains.**—1. *Rubber tubes.* Very small tubes are useless, as they become plugged by coagulated discharges. The most useful are those the size of an ordinary lead-pencil or of the little finger. It is rare that larger tubes are necessary, and then only in the form of split tubes covering a wick gauze. The tubes must be perforated laterally and their distal ends should be trimmed in a fish-tail fashion (Fig. 1618). The tube may be prevented from slipping into the body by being stitched to the skin or provided with a guard in the

FIG. 1616.

FIG. 1617.

FIG. 1618.

FIG. 1619.

form of a safety-pin. L. L. McArthur, after sterilizing rubber tubes, soaks them for a week or more in liquid petrolatum. This treatment makes the tubes softer and prevents clotting in them.

2. *Split rubber tubes* are the ordinary tubes split up one side. The split renders the tubes less rigid and less liable to cause pressure necrosis.

3. *Dressed drains* consist of a rubber tube surrounded by a few layers of absorbent gauze (usually iodoform) (Fig 1619) the gauze being in turn covered by thin rubber tissue. The dressed tube is practically a cigarette drain with a tubular core. They are of great value, especially in abdominal surgery.

4. Wetherill's drain is useful in many locations. It is prepared as follows:

Cut two holes in a long piece of drainage tubing as indicated at *A* and *B* (Fig. 1620, 1). Draw one end of the tube through *A* and out at *B*, thus inverting that portion of the tube between the holes as seen in (Fig. 1620, 2). Bend the legs of the tube down so that the holes *A* and *B* will be left open for drainage (Fig. 1620, 3). If bent in one direction they are open, if in the other, closed. Tack with a fine stitch at *C*.

5. *Rigid tubes of glass, hard rubber, celluloid,* These may be provided with a collar, made fro through which a safety-pin or stitch may be ins against the slipping of the tube into the wound.

C. **Combined capillary and tubular drainage** m any of the ordinary capillary drains with a tubul containing a bunch of silkworm-gut threads.

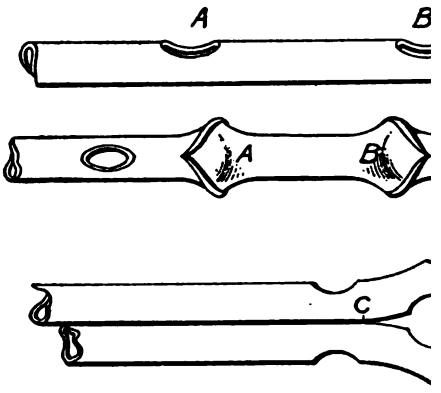

FIG. 1620.—Wetherill's dra

D. **Absorbable Drains.**—The use of catgut as been noted. Neuber suggested drains of decalcifi duced the inexpensive chicken-bone drain.

Preparation of Chicken-bone Drainage tubes.— and femora of chickens (cooking the chicken does r a 20 per cent. solution of hydrochloric acid until so of the bone with scissors. Raise the endosteum a to the other extremity along with its contents. S

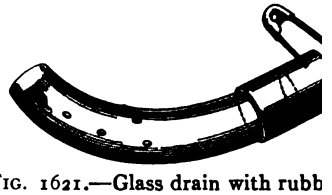

FIG. 1621.—Glass drain with rubb

rated solution of ammonium sulphate. With steril wash off the sulphate of ammonium. Preserve i iodoform in alcohol or ether and alcohol. These t in the tissues. If greater durability is desired (*e.g.* cerebral abscesses), soak in a sterile solution of chr

Macewen recommends that when bone drains a be threaded with horse-hair to prevent plugging encourage capillary drainage. After a day the ha tube patent.

CHAPTER CXII

ACUTE ABSCESS

Acute abscesses ought to be drained as early as possible after diagnosis. The operation should be performed under antiseptic precautions. This is important because of the danger of causing increased or mixed infection, *e.g.*, grafting a streptococcic on to a staphylococcic infection.

Local anesthesia is usually sufficient to prevent suffering. When an abscess is superficial, pass the knife steadily through the skin and subjacent tissues until pus is reached. This should be done at the most prominent or most dependent part of the swelling. As the knife is withdrawn the wound may be enlarged. A good guide as to the size of the opening to be made is the size of the surgeon's fingers. In a small and not deeply situated abscess the little finger can explore the whole cavity; in larger abscesses the index finger must be used. The opening should be made of sufficient size to admit the exploring finger.

When the abscess is deep, Hilton's method of operating is safe and excellent. An incision about 1 or 1½ inches in length is made over the most prominent or dependent part of the swelling. The incision penetrates the skin and deep fascia. A grooved director, which must not be too sharp, is insinuated through the tissues in the direction of the pus until pus flows along its groove. The point of a narrow-bladed hemostat or blunt-pointed scissors is passed along the director into the abscess cavity. The blades of the instrument are now opened and made to dilate the opening to an appropriate size. Frequently counter-openings are required. Such may be made by passing the point of a hemostat into the abscess and pushing it out through the tissues until the skin is reached. The skin elevated by the point of the forceps is divided, the blades of the forceps are opened to enlarge the passage, a drainage-tube is seized by the forceps, and as the instrument is withdrawn, the tube is pulled into position. An abscess having been opened, its cavity ought to be douched thoroughly with warm water or a mild antiseptic solution until the solution returns clear. Dakins' solution is often of value especially when used by Carrel's method. Any gross sloughs or masses of débris should be removed with forceps, finger, or sharp spoon. The last-named instrument should not be used too vigorously lest nature's defense against absorption, viz., granulation tissue, be too thoroughly removed, or violent hemorrhage or persistent oozing started.

Drainage-tubes must be inserted through the openings. Young practitioners often delight in the use of tubes about the size of a crow-quill; such are almost useless, as the fluid to be drained is thick and speedily chokes them. Rubber tubes which vary from the size of an ordinary lead-pencil to that of the little finger are the best; no object is to be attained by using sizes much larger. The external end of the tube must be kept from slipping into the wound, either by being stitched to the skin or by having a large safety-pin passed through it.

Bier and Klapp obtain excellent results by merely puncturing the abscess and then sucking out the pus by means of cupping glasses. In palmar abscess

this treatment is specially good. The suction ought not to be vigorous enc to cause pain; it ought to be applied for five minutes and left off for two min alternately, for about forty-five minutes night and morning. (Bier, "Hy ämie als Heilmittel.")

J. B. Murphy instead of opening and draining abscesses, aspirates the and then injects formalin glycerine (formalin, 2; glycerine, 98) in quar sufficient to produce slight tension. The solution ought to be kept at l 24 hours before being used. If a tuberculous bone lesion is present he : 10 per cent. of iodoform to the above mixture. He employs this treatmer empyemata of the chest and of joints.

Dressings.—Ordinary, voluminous antiseptic dressings must be app in such a manner as to collect the discharge and at the same time exe elastic pressure on the abscess so as to keep it collapsed as much as pos and prevent reaccumulation of fluid.

PSOAS ABSCESS

Treves' Operation.—The patient is placed on his side with the dise side uppermost. Under the opposite loin there is placed a sand-bag. incision 2½ to 3 inches in length is made parallel to and beside outer edge of the erector spinæ muscle (*i.e.*, about 3 inches from spinous processes). The middle of this cut corresponds to a p midway between the last rib and the iliac crest. The dense apo rosis covering the erector spinæ is divided throughout the w length of the wound. The outer edge of the muscle is demonstr and then strongly retracted towards the spine. This expose layer of fascia (middle layer, fascia lumborum) which covers quadratus lumborum. By palpation find the transverse processe the lumbar vertebræ and divide the fascia as close to them as p ble. The thin quadratus lumborum muscle now comes into v and according to Treves it must be divided close to a transv process. The next tissue met is the psoas muscle, and when s of its tendinous fibres have been divided close to a transverse proc the fingers can be "introduced beneath the muscle and gently insi ated along the process until the anterior aspect of the bodies the vertebræ is reached."

FIG. 1622. Irrigating curette.

Where there is a large psoas abscess the patient is alm always much emaciated and the tissues over the abscess are th so that after the quadratus lumborum muscle has been exposed grooved director may be insinuated into the abscess cavity and entrance gained by Hilton's method. Having gained access to t abscess, it is thoroughly douched with hot water or a hot antiseptic solutio The writer often uses a sherry-colored solution of tincture of iodine in h water. The lining membrane of the abscess is to be scraped away wit finger-nail and sponge (Treves) or with the irrigating curette (Barker) (Fig 1622). This must be done cautiously, as the anterior wall of the abscess is usually thin. All pockets leading from the main abscess are explored and scraped with the finger. All accessible portions of the spine are palpated, and

any tuberculous nodules are found they are, if possible, to be removed. Having douched and cleaned and douched again, until the fluids return clear, the cavity is dried, two or three ounces of iodoform emulsion are thrown into it, and the wound is closed without drainage. The abscess may recur and require a second operation.

The after-treatment consists in rest under hygienic conditions, and must be carried out for many months.

The great advantage of the Treves operation is the access it gives to the spinal column—to the focus of the disease.

Should the abscess have opened of itself in the thigh, it must be treated on the ordinary surgical lines, *i.e.*, counteropenings must be made to provide efficient drainage.

CHAPTER CXIII

OPERATIVE TREATMENT OF NEOPLASMS

Indications for the Excision of Tumors.—It is frequently said that all neoplasms ought to be removed. The general rule is correct but, to it there are many exceptions. The warts on a small boy's hands disappear spontaneously. A lipoma or fibroma may cause little or no inconvenience, and yet be so situated anatomically that its excision might give rise to serious danger to life, or might so injure or destroy neighboring structures (nerves, etc.) as to far outweigh any benefit to be hoped from its removal. The removal of many neoplasms is a matter of choice as they are unlikely to become malignant, and excision is only sought because of their inconvenience, size or unsightliness. One must not forget that the most innocent looking neoplasm may have hidden in it the possibilities of malignancy. In other circumstances the anatomic situation of a non-malignant tumor may demand immediate operation, *e.g.*, it may cause pressure on the trachea, etc.

Warts, moles, fibromas and such-like non-malignant neoplasms of the skin and accessible mucous membrane are easily excised. It is important to remove the whole thickness of the skin with the tumor otherwise even a small wound becomes difficult to close. If the growth is large the resulting wound must be closed either by one of the methods described under plastic surgery or by skin grafting. Keen recognizing that pigmented moles often recur after excision and give rise to very malignant melanotic growths advocates their *thorough* removal. Bevan thinks that a single pigmented mole is much more likely to be the precursor of malignancy than are multiple moles.

It has been suggested that moles should be destroyed by the cautery and the resultant scar immediately excised (Bevan). The object of this is of course to prevent the disturbance and dissemination of the cellular elements of the mole. As a rule the author prefers destroying small non-malignant moles by means of carbon dioxide snow to excising them.

In excising a non-malignant neoplasm it is only necessary to remove the tumor itself, it is not necessary to "cut wide of the mark" or to concern oneself with the lymphatics.

The basal-celled epitheliomata of the face (rodent ulcer, etc.) are commonly only of local malignancy and free excision gives good results, the lymphatics not being involved at least until late. These are the tumors which are often cured by means of the X-rays.

Sampson Handley ("Universal Med. Record," 1912, p. 385) strongly urges "the inadvisability of trusting long to radio-active therapeutics as the first line of defence," even in superficial and early malignant growths, "unless the disease rapidly and completely yields."

Melanoma of Skin. (Melanotic Sarcoma).—Handley is of the opinion that melanotic tumors spread by lymphatic permeation, *i.e.*, by growing into and along the lymphatic channels centrifugally in all directions, and that dissemination through the vascular system is a later phenomenon. Based on this opinion he operates as follows:

1. Make a circular incision around and about one inch from the tumor. If necessary supplement the circular incision by two radial linear incisions on opposite sides of the tumor. These cuts (circular and linear) penetrate the skin alone (Fig. 1623).

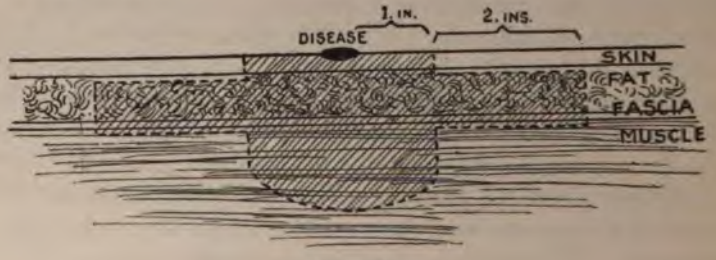

FIG. 1623.

2. Elevate the skin with a thin attached layer of subcutaneous fat, from the deeper structures for a distance of about two inches in all directions from the original circular incision.

3. At the extreme base of the elevated skin flaps make a circular incision penetrating the subcutaneous fat, the deep fascia and a few fibres of the subjacent muscles.

4. Beginning at the outer circular incision elevate the deep fascia from the muscles, dissecting towards the tumor, until a point is reached immediately beneath the first circular or skin incision. Remove the whole mass by scooping out with a knife a circular area of muscle immediately beneath the tumor.

5. Close the wound. Thoroughly excise the chain of lymph glands next in order, into which the affected area drains. The glands ought to be removed whether apparently affected or not, "and this is most important—the apparently healthy set of glands above those obviously enlarged should be completely removed." The following case of Sampson Handley's is so important and striking that it demands attention:

"Miss C., aged forty, * * * October 21, 1909. In September, 1907, Dr. Moreton Palmer removed an ulcerated papilloma which had been present on the dorsum of the left wrist for three or four years. In September, 1908, some small lumps were removed just above the epitrochlear gland. These lumps were subcutaneous and were not glandular. A week or two

later, a small dark nodule appeared just below the incision. It was removed under local anesthesia and was reported by the Clinical Research Association as a malignant melanoma. Subsequently the patient suffered much pain in the bicipital region, thought to be due to an involvement of nerves in the scar. On examination I found a vague induration running up the axillary vessels about the middle of the upper arm, midway between the axilla and the scar of the second operation, and it appeared probable that the growth was recurrent in this situation. Moreover, a large gland, nearly as big as a chestnut, could be felt in the axilla. I, therefore, advised a thorough operation which should include removal of the supraclavicular glands, clearing of the axilla, and excision of the deep fascia, extending from the axilla almost to the elbow. The patient consented to undergo the operation and was admitted to the Bolingbroke Hospital. A semilunar flap of skin, involving most of the inner aspect of the arm, was turned backwards, and the deep fascia was widely removed with exposure of the brachial vessels and accompanying nerves. The axilla was next opened by a prolongation of the first incision into its fornix, and was completely cleared of its fat and glands, which were removed in continuity with the deep fascia of the inner side of the arm. The supraclavicular triangle was now cleared of its fat and glands through a separate incision. The patient made a good recovery from the operation. About a year later a recurrent nodule appeared over the lower part of the triceps at the back of the arm. It was excised on December 15, 1909, and, on section, was a typical sarcoma, unpigmented and degenerated at the centre. (It is well known that unpigmented metastases are not rare in melanotic sarcoma.) Since this time the patient has remained well, and the neuralgic pains from which she suffered in the arm have greatly improved, especially since a visit to Sidmouth, where she had hot sea-bathing treatment."

In support of Handley's views regarding lymphatic permeation and the value of operation the following case may be of interest. In Aug., 1916 the author removed a melanoma from in front of the ear and at the same time excised lymph nodes below the angle of the jaw, these nodes being densely black and enlarged. At the time it was felt that more extensive excision was desirable but the condition of the patient would not permit. In Feb., 1917, there was no evidence of recurrence. In Oct., 1918, a metastatic skin lesion near the left nipple was removed during the author's absence in the army. Death ensued from multiple metastases in Aug., 1919, three years after the original operation.

CHAPTER CXIV

LIGATURES AND SUTURES

I. Non-absorbable.—The principal non-absorbable ligatures or sutures are: (*a*) Silk; (*b*) Pagenstecher's or Braun's celluloid hemp; (*c*) silkworm-gut; (*d*) horse-hair; (*e*) wire (silver, gold, aluminium-bronze). All the above materials are strong, of uniform size, capable of being easily and securely tied or fastened, and sterilized by being boiled or steamed.

Silk is the material most commonly used for intestinal sutures and for non-absorbable ligatures. Celluloid hemp (in the smaller sizes) possesses all the advantages of silk, and, in addition, it has less capillarity, and being stiffer, can be readily threaded into fine needles even when wet. These two peculiarities are of great value in operations on the intestine. The want of capillarity prevents, to some extent at least, infection passing along the thread, as intestinal sutures very commonly include part of the mucosa even when introduced with the greatest care. The convenience of being able to thread a needle with the wet material is self-evident. Celluloid hemp is stronger than

silk, but its surface is not so smooth. Thick celluloid hemp ligatures are not so easily drawn into a tight knot as are silk ones and possess no advantage over the latter. Braun's thread is smooth and easily knotted. For sterilization celluloid hemp requires to be boiled longer than does silk.

The most convenient sizes of silk or hemp are Nos. 1, 2, 3, and 4. For intestinal sutures and the ligature of small vessels, Nos. 1 and 2 are excellent. No. 4 is used for tying large pedicles.

Preparation of Silk or Hemp.—Wind the thread on glass spools or tubes, preferably in one layer. Boil in water or 4 per cent. soda solution for fifteen or thirty minutes (along with the instruments). Soak in corrosive sublimate solution 1 : 1000. The advantage of using the antiseptic solution is that it inhibits the growth of any bacteria which may accidentally gain access to the ligature during the operation.

Kocher is the most enthusiastic advocate of silk. He prepares his ligatures as follows: Soak the silk in ether for twelve hours; then in alcohol for a like period. Boil for ten minutes in a 1 : 1000 solution of sublimate (the sublimate solution must neither be colored nor acidulated). Use the silk directly from the sublimate solution. As pulling thread between the fingers of the operator is liable to infect it, Kocher always wears gloves when tying ligatures, even when he does not wear them for the other steps in the operation.

When silk is to be used for intestinal work, it may be sterilized by steam, and being dry, is easily threaded on needles. If to be sterilized by boiling, the requisite numbers of needles should be threaded beforehand and stitched into a towel in such a manner that they can be easily pulled out but cannot become entangled while being boiled.

Waxed Silk, Hemp or Linen. (McArthur, Surgery, Gynecology and Obstetrics, 1913, Volume XVI, page 460).—This material was devised by Moses Gunn. "The silk is cut in proper lengths, wound upon pieces of cardboard which are then folded in pieces of paraffin paper and put in an envelope with the size and length of the suture inscribed upon it These packets are then dry sterilized in bulk in an ordinary dry sterilizer. When a sufficient quantity has been made, the envelopes are opened, the silk cards are immersed in the 10 per cent. carbolized melted beeswax under the usual modern aseptic precautions, and when saturated are returned to the envelopes. Before using, the silk should be rapidly drawn through a sterile towel. This produces enough friction to partly melt the wax and thus polish the silk, just as the shoemaker polishes his wax end.

This suture material then possesses all the desirable qualities of any suture material. It is solid like silver wire, smooth like silkworm; unirritating, it may be buried, is stronger for the size than the unwaxed, and has as its nearest imitator, Pagenstecher linen. It makes the ideal suture for delicate structures like the peritoneum, intestinal anastomosis, dura and skin. It seems to have just sufficient antiseptic effect from the carbolic acid to permit its remaining from 10 to 14 days without exciting suppuration if the skin be sterile at the time of insertion.

"Emphasis should be laid upon the necessity of securing *true beeswax*, not the "improved" bleached variety which is usually paraffin, as well as 100 per cent. phenic acid."

Silkworm-gut.—This, the common fishing gut, is prepared from the silkworm when it has got into condition to begin spinning. The material used is, in fact, the silk before it is spun. Silkworm-gut is an ideal, smooth, strong, non-porous, non-absorbable suture. It is easily sterilized by boiling, which at the same time softens it and renders it easy to tie. If used dry, the gut is hard and too brittle to tie. It may be obtained in various sizes, from the thick and very strong gut used by salmon fishers to the extremely fine "drawn gut" of the English dry fly fishermen.

Horse-hair possesses the advantages of fine silkworm-gut, but is better in that its elasticity prevents cutting of the tissues. It is ideal material for fine skin sutures, as it leaves little scar. It is prepared for use by a thorough washing in soap and water and then by boiling.

Silver Wire.—This is the most common suture used for uniting bones. Some surgeons use it extensively for buried sutures. Its ends are easily secured by twisting. Sterilization is effected by boiling. The metallic silver is an antiseptic *per se.*

II. Absorbable Ligatures and Sutures.—(*a*) Catgut; (*b*) Tendon.

Catgut.—The most common absorbable ligature is made from the submucous coat of the intestine of sheep. The best catgut comes from Germany and Sweden. The American sheep suffer from some intestinal disease which renders their submucosa useless for the manufacture of catgut. The most convenient sizes of catgut are Nos. 0, 1, 2, 3. No. 4 is occasionally of service, but is very thick.

Catgut may be used plain or may be treated with some material which renders its absorption by the tissues more slow (chromic acid, formalin). There are a very great number of methods by which sterilization may be effected; only a few of these will be detailed here. Several manufacturers prepare reliable catgut in convenient receptacles, *e.g.*, in hermetically sealed glass tubes, in air-tight envelopes, etc. Such catgut is usually sterilized by dry heat in the fractional method. The process is more or less complicated and will not be described, as simpler and equally efficacious methods are available. The cumol method of sterilization seems to be reliable, but requires considerable experience to be carried out in safety. Bartlett's iodized catgut is very reliable and may be obtained ready for use in tubes.

Preparation of Catgut.—Wind the catgut in a single layer on glass tubes. In doing this it is very important to rotate the tubes and, holding the gut tight, allow it to be wound on to the tube. If one twists the gut on to the tube, as it passes through the fingers its fabric is liable to become untwisted and its strength ruined. Fasten the end of the thread so that it will not come undone.

Methods of Sterilization.—(I) Elsberg's method (modified): Make a saturated solution of sulphate of ammonium in water. Boil this solution and see that it is saturated while boiling. Boil the catgut in this for twenty minutes. With sterile forceps place the gut in sterile water or antiseptic solution to remove the sulphate of ammonium. This does not consume more than a minute. Preserve the gut in alcohol or in a saturated solution of iodoform in alcohol and ether. Elsberg before boiling soaks the gut for twenty-four hours in a mixture of chloroform and ether. This is unnecessary.

II. Claudius' method (I, KI, catgut): Soak the gut (wound on tubes) i eight days in the following solution: iodine, 1 part; iodide of potassium, 1 pa water, 100 parts. The gut is now ready, and may be used directly from the so tion or after washing in sterile water or some antiseptic solution. The auth prefers using it directly from the iodine solution. It is claimed that the cat may be kept indefinitely in the solution, but this is incorrect.

Salkindsohn modifies the above in a happy fashion by using a mixture tincture of iodine 1 part in 15 parts of proof (*i.e.*, 50 per cent.) spirit. Iodi catgut has given great satisfaction to the author.

G. G. Macdonald has tested Salkindsohn's catgut. His results are sho in the accompanying table (p. 1267).

III. Yelverton Pearson ("Brit. Med. Journ.," Dec. 25, 1909) advocates use of "iodine-formalin" catgut when a resistant suture is desired. The is prepared as follows:

1. Soak in an alcoholic solution of iodine (1 per cent. iodine, 54 per c alcohol).

2. After eight days remove from the iodine solution and wash in a weak c bolic solution or in running sterile water "to remove the alcohol and iodine fr the outer layers so as to permit more freedom for the action of the formalin."

3. Soak in 3 per cent. formalin solution for from 24 to 48 hours, accordin the thickness of the gut.

4. Wash in running water for a few hours to remove the formalin.

5. Place in 50 per cent. alcohol containing ½ per cent. iodine and 5 per c glycerine. This preserves the gut indefinitely.

IV. Iodine-acetone catgut. McDonald's method ("Am. Journ. of Sur May, 1910):

Sol. 1.—Iodine 4 per cent. in acetone, soak eight days, drain off solution

Sol. 2.—Acetone, soak four days, drain off then cover with.

Sol. 3.—Acetone 85 per cent., Columbian spirits 10 per cent., glycerin per cent.

Dissolve glycerine in spirits then add to the acetone. Keep the gut in t indefinitely.

V. Biniodide catgut:

Mercuric iodide, 1.
Potassium iodide, 4.
Alcohol, 1000.

Soak the catgut in this solution for one week before using. The same solut preserves the gut indefinitely.

C. H. Watson (Surg. Gyn. Obst., XXII, p. 114) finds that a 1 : 1000 al holic solution of potassium mercuric iodide is not only far more powerful t 1 per cent. iodine but that it increases the tensile strength of the gut.

VI. Saul's method: Put the gut (wound on tubes) into a pot provided w a condenser. Cover the gut with a solution of carbolic acid 5 parts, 90 per c alcohol 100 parts. Boil for twenty minutes. Preserve the gut in alcohol or i solution of iodoform in alcohol or alcohol and ether. Experiment shows t gut, soaked in a culture of anthrax and covered with grease, is sterilized by above method after seven minutes of boiling.

STERILIZATION OF CATGUT BY IODINE-SPIRIT METHOD

Time in iodine-spirit	15 minutes	30 minutes	1 hour	2 hours	3 hours	5 hours	6 hours	1 day	2 days	3 days	4 days	5 days	6 days	7 days	8 days	9 days	10 days
Commercial catgut, wound on spools and placed in iodine-spirit for varying periods, as following: (In the catgut Staphylococcus, B. prodigiosus and some sporing organisms were found by cultivation.)	Grew Staphylococcus aureus, B. prodigiosus and a sporing organism	Grew Staphylococcus aureus, B. prodigiosus and a sporing organism	Staphylococcus and sporing organism. No. B. prodigiosus	Staphylococcus and sporing organism	No Staphylococcus. Sporing organism	Sporing organism	Sporing organism	Sporing organism	Sporing organism	Sporing organism	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile
Sterilised catgut infected with Staphylococcus pyogenes aureus, as above.	.....	Staphylococcus pyogenes aureus	Staphylococcus pyogenes aureus	Staphylococcus pyogenes aureus	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile
Sterilised catgut infected with Bacillus typhosus, as above.	B. typhosus	B. typhosus	B. typhosus	B. typhosus	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile
Sterilised catgut impregnated with anthrax spores. (Killed by 4–7 minutes boiling.)	.....	.....	B. anthracis	.....	.....	.....	B. anthracis	B. anthracis	B. anthracis	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile
Sterilised catgut infected with spores of Bacillus mesentericus (resisted 18 minutes at 100 °C.)	.....	.....	.....	B. mesentericus	.....	B. mesentericus	.....	B. mesentericus	B. mesentericus	B. mesentericus	B. mesentericus	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile
Sterilised catgut (tied in skeins) infected with spores of Bacillus mesentericus more resistant than the above (being) killed by 23 and not 20 minutes boiling).	.....	.....	.....	B. mesentericus	.....	B. mesentericus	.....	B. mesentericus	B. mesentericus	B. mesentericus	B. mesentericus	B. mesentericus	Sterile	Sterile	Sterile	Sterile	Sterile

penetrate the gut, and that, as a consequence, the inside of th
exposed to a *dry* heat of 212° F., which does not sterilize.

The methods of sterilization here described have all be
author and found satisfactory. In none of them is it necess
gut with the fingers from the time the sterilization begins unt
in operating. Any one of the methods described is as safe as
biniodide method is perhaps the easiest and cheapest.

Tendon.—The tendons of such animals as the kangaroo, re
have been much used for sutures and ligatures. Many surgeo
catgut. Sterilization may be effected as with catgut. The r
the use of tendon is its expense.

CHAPTER CXV

WOUNDS

The treatment of wounds involving such structures as b
has been sufficiently described in other chapters. In the pr
endeavour will be made to outline the treatment of the more s
the soft parts, both recent wounds and those which have beco

Every war wound and most wounds in civil life must be
taminated and if the contamination is not removed within al
they must be considered infected. Except when a wound is
cutting instrument there is always a zone of bruized, more o
tissue next to the cut surface. This zone varies in extent and is
the development of bacteria. Lessons gathered from war exp
be used in civil life.

1. **The wound is clean cut and free from foreign bodies,**

(Debridement). A healthly bleeding surface should be attained. Open and clean all pockets. Attend to hemostasis. Close the wound with or without drainage.

3. The wound is as in '2' but the patient cannot be kept under observation until the danger of acute infection is passed. Treat as above, but instead of closing the wound fill it loosely with sterile gauze and apply dressings. Instead of plain gauze one may use gauze soaked in liquid paraffin, in hypertomic salt solution, in a 1 : 5000 watery solution of flavine, in Dakin's solution, etc. Many surgeons institute the Carrel-Dakin method at once. During a 'war of movement' the wounds are usually treated as above in the Evacuation Hospitals and the patients are sent as quickly as possible to Base Hospitals, where the wounds are sutured if clean, or are sterilized and later closed. If the wounds have remained clean after the 'debridement' and circumstances permit of their being sutured within 3 or 4 days (delayed primary suture) closure is easy and safe as there has been no time for granulation tissue and scar tissue to be formed. Late or secondary suture is more troublesome to carry out.

4. The wound is infected. Every nook and cranny of the wound must be rendered freely accessible. Loose gauze dressings moistened and kept moist with antiseptics must fill every part of the cavity or the Carrel-Dakin method may be utilized as follows:

"Preparation of Dakin solution (technique of Daufresne): The solution of sodium hypochlorite for surgical use must be free of caustic alkali; it must only contain 0.45 to 0.50 per cent. of hypochlorite. Under 0.45 per cent. it is not active enough and above 0.50 per cent. it is irritant. "With chloride of lime (bleaching powder) having 25 per cent. of active chlorine, the quantities of necessary substances to prepare 10 litres of solution are the following: 200 grams chloride of lime (bleaching powder) (25 per cent. active chlorine). 100 grams sodium carbonate dry (soda of Solway). 80 grams sodium bicarbonate dry.

Put into a 12 litre flask the two hundred grams of chloride of lime and five litres of ordinary water, shake vigorously for a few minutes and leave in contact for six to twelve hours, one night for example. (Shake until dissolved—at least until the big pieces are dissolved. Not all the pieces will dissolve, large pieces float, notice only floating pieces.)

At the same time, dissolve in five litres of ordinary cold water the carbonate and bicarbonate of soda. After leaving from six to twelve hours, pour the salt solution in the flask containing the macerated chloride of lime, shake vigorously for a few minutes and leave to allow the calcium carbonate to be precipitated. In about one-half hour siphon the liquid and filter with a double paper to obtain a good, clear liquid, which should always be kept in a dark place.

"Titration of chloride of lime (bleaching powder). Because of the variation of the products now obtained in the market, it is necessary to determine the quantity of active chlorine contained in the chloride of lime which is to be used. This must be done in order to employ an exact calculated quantity according to its concentration.

"The test is made in the following manner: Take from different parts of the jar, a small quantity of bleaching powder to have a medium sample, weigh 20 of it, mix as well as possible in a litre of tap water and leave in contact a few hours. Measure 10 cubic centimeters of the clear liquid and add 20 cubic contimeters of a 10 per cent. solution of potassium iodide, 2 cubic centimeters of acetic acid or, to free all hydrochloric acid, then put drop by drop into the mixture a decinormal solution of sodium hyposulphite (2.48 per cent.) until decoloration. The number N of cubic centimeters of hyposulphite employed, multiplied by 1,775 will give the weight N of active chlorine contained in 100 grams of chloride of lime.

"The test must be made every time a new product is received. When the result obtained differs more or less than 25 per cent., it will be necessary to reduce or enlarge the proportion of three products contained in the preparation. This can easily be obtained by multiplying each

of the three numbers, 200, 100, 80 by the factor $25N$ in which N represents the weight of the active chlorine per cent. of chloride of lime.

"*Titration of Dakin Solution.*—Measure 10 cubic centimeters of the solution, add 20 cubic centimeters of potassium iodide 1 : 10, 2 cubic centimeters of acetic acid and drop by drop a decinormal solution of sodium hyposulphite until decoloration. The number of cubic centimeters used multiplied by 0.03725 will give the weight of hypochlorite of soda contained in 100 cubic centimeters of the solution.

"Never heat the solution, and if in case of urgency one is obliged to resort to trituration of chloride of lime in a mortar, only employ water, never salt solution.

"*Test of the Alkalinity of Dakin Solution.*—To differentiate easily the solution obtained by this process from the commercial hypochlorites, pour into a glass about 20 cubic centimeters of the solution and drop on the surface of liquid a few centigrams of phenolphthalein in powder.

"The correct solution does not give any coloration, while Lebarraque's solution and eau de Javel will give an intense red color which shows in the last two solutions existence of free caustic alkali.

"The stock solution should be kept in blue or brown colored bottles, well corked." (*Sherman, Surg. Gyn. and Obst.*, xxiv, 258.)

The Carrel apparatus consists of a graduated container connected with a glass distributor by means of a rubber tube which is interrupted by a glass drip to indicate the rate and amount of solution flowing from the container. Tubes of pure rubber about 15–25 cm. to (6 to 10 inches) long are prepared by having their distal ends tied off with silk or linen and having a number of very tiny holes punched in such parts of the tubes as are to lie in the wound. The proximal ends of the tubes are attached to the distributor. The number of the tubes depends on size and depth of the wound.

Arrange the tubes in the wound in such a manner that they can distribute the Dakin's solution evenly to every part of it. Place strips of gauze loosely between the tubes so as to keep them in position. Fill the wound cavity *loosely* with gauze. No packing is permissible. Apply an outer dressing of Turkish toweling or of a few layers of gauze covered by a layer of *non*-absorbent cotton lightly held in place by a bandage. Protect all the skin around the wound with strips of gauze soaked in sterile vaseline. Charge the container with Dakin's solution and permit enough of the solution to flow through the tubes to fill the wound. Note the amount of solution required for this purpose. Every two hours both night and day fill the wound with the required amount of solution. The container should never be elevated more than 3 feet above the patient.

Re-dressing.—Each day remove the dressings with sterile forceps. Clean and sterilize the tubes. Remove vaseline from the skin with ether. Cleanse the wound and the skin by mopping with neutral oleate of soda solution. Mop the wound with Dakin's solution. Apply vaselinized gauze to the skin and reintroduce the tubes as before.

As soon as the wound appears clean it is wise to take 'smears' from various parts of it and examine such microscopically, when each microscopic field shows no more than 2 or 3 cocci for several days, it may be considered clinically sterile. The presence of true streptococci especially hemolysing streptococci, forbids attempts at suture. Cultures made from the exudates are particularly valuable. Of course no instillations should be made for several hours before cultures are taken.

Secondary Suture.—As soon as a wound is clinically sterile, endeavours should be made to close it: Sterilize the skin. Wipe the wound clean. Excise the skin margins. Remove excess of granulation tissue. Excise scar tissue. With buried sutures of catgut or with relaxation sutures of silk or silkworm gut carefully bring together the tissues layer by layer, obliterating all dead spaces. To accomplish this, it may be necessary to undermine both fascia and skin. Relaxation incisions may often be required. Properly applied strips of adhesive plaster are often of great value. Frequently in large, gaping, old wounds it may be impossible to obtain apposition even in the depth of the wound, but if the wound is narrowed it will be possible to close it by a subsequent operation.

CHAPTER CXVI

LOCALIZATION OF FOREIGN BODIES

By the Late Walter S. Sutton, M. D., F. A. C. S. and
Edward H. Skinner, M. D.

Aside from the visual recognition of incompletely covered foreign bodies, there are three general methods of localization.

(1) By palpation, directly or by means of instruments.

(2) By magnets.

(3) By the use of the Roentgen ray.

1. **Palpation.**—Of manual palpation, nothing need be said. Palpation by means of probes falls into two classes. That by means of a simple probe, and that in which the telephone probe is employed.

In spite of the dictum of von Bergmann, it is undeniable that the naked probe has a useful function in the localization of foreign bodies in war. Fine-pointed probes undoubtedly have a tendency to open new planes to infection, but large probes, with bulbous extremities not less than ⅛ inch in diameter, have proved harmless and efficient in locating foreign bodies at the bottom of well-defined penetrating wounds. If the probe is held so lightly between thumb and index-finger that it may be gently rolled back and forth as its point is advanced, it will not make false passages and will frequently permit the expeditious localization of suspected foreign bodies.

The Telephone Probe.—To obviate the difficulty not infrequently experienced in recognizing the contact of probe and foreign body, MacKenzie Davidson has urged the employment of the telephone probe and has devised means of using the telephone attachment on any instrument employed in this operation. The action of this instrument depends on the fact that small electric currents are generated by contact of dissimilar metals. The apparatus consists of one or two small telephone receivers adjusted to the ear or ears of the operator, one pole of the circuit being connected with a moistened carbon plate on the patient's skin and the other with a probe or other instrument.* One or two dry cells introduced into the circuit increase the effectiveness of the apparatus. When the instrument employed for palpation touches a foreign body, a distinct click is heard in the receivers. Care need only be taken that the click heard

* Mr. Gillies has shown that the moveable end of the circuit may be applied through the medium of a copper plate to the arm of the operator instead of directly to probe. In this case, of course, rubber gloves cannot be used.

is not elicited by accidental contact of the probe with a retractor or other instrument. To prevent confusion from this source, probes for the purpose are sometimes covered with vulcanite or some other non-conductor except at their tip, a device which also removes uncertainty as to what portion of the probe has touched the foreign body.

2. **Magnets.**—Localization of magnetic projectiles by means of simple electromagnets is of limited usefulness in war on account of the depth of the foreign bodies and the limited range of the magnets, but Prof. Bergonie of Bordeaux, by introducing a motor-driven current-reversing device in the circuit, has greatly extended the scope of this means of localization. As the pole of the magnet is passed over the surface of the body, a finger being interposed, nearness of a magnetic foreign body is revealed by a purring sensation transmitted through the skin. The pole-extension of the magnet may be sterilized and as the incision is carried down, the purring becomes stronger until on near approach, a visible vibration of tissue reveals the site of the foreign body to the eye.

3. **Localization by use of Roentgen rays** may be fluoroscopic or radiographic. For obvious reasons, the former is preferable in cases where the latter does not present special advantages.

Fluoroscopic Methods.—In some cases sufficient information may be obtanied by very rapid and simple methods.

Palpation Under the Screen. Near Point Method (U. S. Army).—Superficial foreign bodies not recognizable by simple palpation, may be located by palpating or percussing the overlying tissues under the fluoroscopic screen. The point on the surface at which pressure or percussion produces the greatest excursion of the shadow of the foreign body, is obviously most directly above the latter. This point is marked with silver nitrate and the patient placed on the operating table in the attitude in which the observation was made. Incision carried down normal, *i.e.*, perpendicular, to the surface at this point will usually reach the foreign body. When possible, as in most extremity cases, the body should be so placed that the axial ray traverses a plane parallel to the tangential plane of the surface at the point nearest the foreign body, *i.e.*, if the foreign body is in the lateral portion of the thigh, the patient should lie on back or face. In this relation excursions of the shadow are most readily detected.

Parallax Method (U. S. Army).—Ascertaining Relative Depth by Movement of X-ray Tube.—It is well known that the farther an opaque body is from the screen, the greater will be its excursion where the tube is moved in a plane parallel to that of the screen. Thus, if it is desirable to find whether a foreign body lies above or below the bone, a greater excursion of the foreign-body shadow than that of the bone when the tube is moved as described, indicates a deeper position of the foreign body. Conversely, if the excursion of the foreign-body shadow is less than that of the bone shadow, the foreign body must be superficial to the bone. If both are equal, the foreign body lies in the plane of the bone.

Fluoroscopic Localization in One Plane.—Fluoroscopic Triangulation. Tube Shift method with Mechanical Triangulation (U. S. Army). This method was first advanced by MacKenzie Davidson. In its simplest form, it is carried

out as follows. With the tube underneath the table and a fluoroscopic screen firmly supported above the patient in a horizontal position and at a known distance from the tube, find the shadow of the foreign body. Close the diaphragm (which must be centered with the target of the tube) to the smallest aperture that will show the shadow of the foreign body. Mark on the screen the position of some definite point on the contour of the latter. For the sake of accuracy, this marking is best done by means of sharp-pointed metal indicators which may be fastened to the frame of the screen.

Move the tube in the horizontal plane a known distance and mark the new position of the chosen point of the shadow contour. Make a chart as shown below (Fig. 1624) indicating graphically the two positions of the anti-cathode,

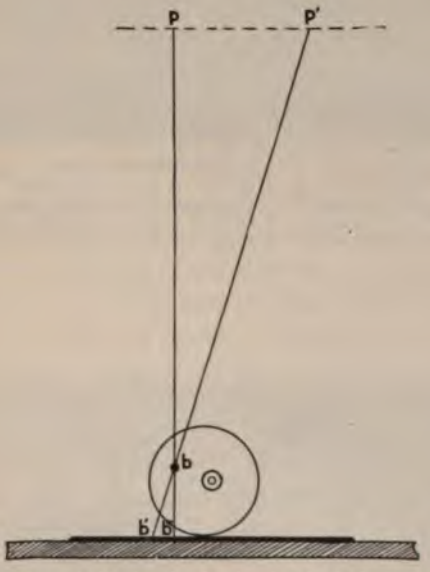

FIG. 1624.—Determination of the depth of a foreign body by radioscopic triangulation.

Pb'' is the distance from level of tube to level of screen (or plate, if radiographic method is used). *P* represents first position of anticathode and *b''* represents first foreign-body shadow. *P'* represents second position of anticathode and *b'* the foreign-body shadow produced in this position. If then the lines *Pb''* and *P'b'* are drawn, their intersection at the point *b* must indicate the locus of the foreign body. The length of the line *bb''* therefore indicates the actual distance of the foreign body from the screen or plate.

the plane of the screen and the two positions of the shadow—all in their actual measurements.

Indicate by two straight lines the axial ray from each position of the anti-cathode to the corresponding shadow. The intersection of these two lines marks the site of the selected point on the foreign body. The actual distance from the screen to this point is then determined by actual measurement on the chart.

The result may be obtained arithmetically according to H. R. Bramwell as follows:

Multiply distance from anti-cathode to screen by amount of excursion of

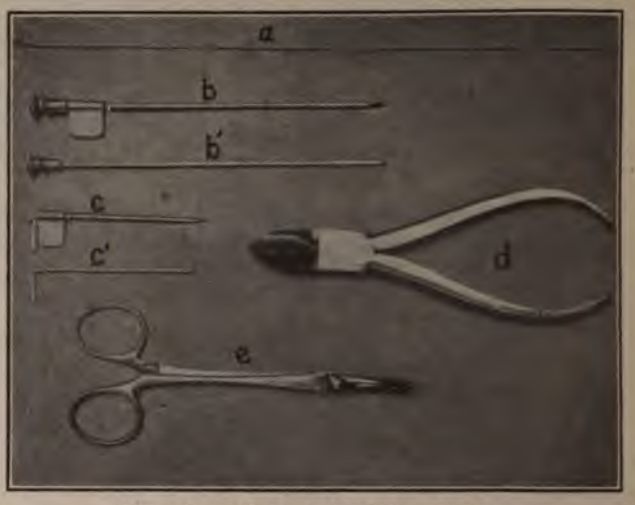

FIG. 1625.—Sutton's localizing device.

c indicates latest form of canula with sharp trocar. *c'* is blunt trocar for use with same canula. *a* curved hemostat for grasping the trocar, *c*. *a* represents the hooked piano wire which is introdu through the canula and left as an indicator. *d* indicates wire cutters employed to snip off the excess pi wire after introduction. *b*, *b'* indicate the original form of the instrument; the large head interfered v "sighting."

FIG. 1626.—Showing method of introducing Sutton's localizing canula. (Plate used by tesy of the *Annals of Surgery*.)

shadow on screen and divide product by sum of amount of displacement of tube and amount of excursion of shadow. Thus, if

A = distance of screen from anti-cathode
S = excursion of shadow, and
T = displacement of tube

the formula $\frac{A + s}{S + F}$ = the distance of foreign body from screen.

Sutton's Method. Canula and Trochar With Harpoon (U. S. Army).—This method was suggested by that of Wullyamoz for removing foreign bodies from the brain. In addition to the tube and screen, a small special instrument is required which, however, is of small cost and may even be improvised. The construction is sufficiently clearly shown in Fig. 1626.

The procedure is as follows:

Having located the shadow of the foreign body by means of the axial ray upon a large screen firmly supported about 6 inches above the surface of the part examined, the surface is painted with iodine, cocainized and a small skin incision made in the center of the shadow. The special canula bearing the blunt or sharp trocar as circumstances may indicate, and held by a strong clamp at right angles, is then entered through the skin incision. The room is then darkened and under the guidance of the X-ray the instrument is driven through the tissues (Fig. 1626). As long as the point is advancing straight toward the anode (and hence toward the foreign body) the shadow of the point will be hidden by the shadow of the upper portion of the instrument.

When the trocar strikes the foreign body, the patient invariably complains of a sharp pain. Contact is then verified by slight waving movements of the point of the trocar which can be made to cause the foreign-body shadow to describe a circular excursion on the screen.

The current is now cut off, the screen removed and the room lighted while the operator continues to hold the trocar immovable. Next the trocar is withdrawn from the canula and one of the small hooked piano-wire indicators inserted in its place. Holding the hook of the latter against the foreign body, the canula is withdrawn and the wire snipped off ¼ inch above the skin. Over this a fairly thick dressing is applied.

If other foreign bodies are present, each may be localized in the same way. On the operating table each indicator may be readily followed to the corresponding foreign body.

The particular advantages of this method are:

(1) Operations may almost always be done under local anesthesia.

(2) Changes in the position of limbs or body do not vitiate the result.

(3) There are no calculations to introduce a possible mathematical error.

(4) The localization may be carried out aseptically without sterilizing the hands.

Radiographic Methods.

Stereoscopic plates are particularly useful in cranial and thoracic cases but are unfortunately, rarely applicable under war conditions.

Radiographic triangulation is done exactly as described for fluoroscc angulation with the exception that a plate is used instead of the scre exposures being made on the same plate. This method is more accura the fluoroscopic one on account of the greater nicety of measurements

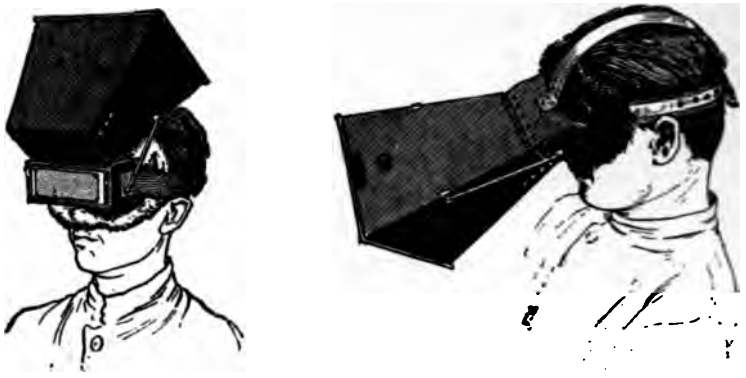

FIG. 1627.

plate as compared with the screen. Radiographic plates in two plan useful in the extremities.

Operative Fluoroscopy.—This method requires the use of the fluoroscc direct localization during the operative removal of foreign bodies. It is

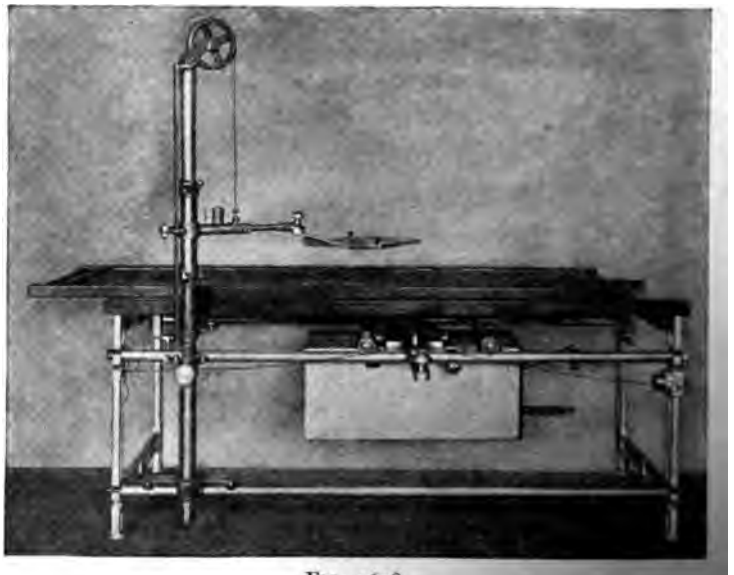

FIG. 1628.

pursued in any operating room where the operating table has a non-opaq and an *x*-ray tube under the table. It is not necessary to darken the op room if the assisting radiologist is provided with a Dessane bonnet (Fig This fluoroscopic bonnet is constructed so that whenever the fluoroscopic

ed the red glass, which protects the radiologist's adaptation to darkness, matically springs from in front of the eyes and vice versa. The approxi- localization of the foreign body has been indicated to the surgeon before patient is placed upon the operating table. After the patient is in position he most favorable operative attack the surgeon makes his incision to the osed location of the foreign body and calls for fluoroscopic advice if he is not ediately successful. By holding a metallic indicator in the wound so that radiologist can advise as to the relative position of the indicator tip to the gn body. Special right-angled forceps may be used under fluoroscopic rol by the radiologist or by the surgeon if he is also provided with a Dessane net. Operations under fluoroscopic control are useful in the thorax, abdo- and in difficult extremity cases. The Standard U. S. Army X-ray table is table for operative fluoroscopy (Fig. 1628).

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